Attachment 11

U.S. Department
of Transportation

**Federal Railroad
Administration**

1200 New Jersey Avenue, SE
Washington, DC 20590

MAY 15 2009

Mr. Thomas Peacock
Director Operations and Technical Services
American Public Transportation Association
1666 K Street N.W. - 11th Floor
Washington, DC 20006

Dear Mr. Peacock:

This letter is in reference to the APTA SS-M-016-06 Standard for Safety Appliances for Rail Passenger Cars petition, submitted by the American Public Transportation Association (APTA), dated September 4, 2007. APTA has proposed minimum industry safety appliance standards for newly constructed passenger cars that are not currently defined in Title 49 Code of Federal Regulations (CFR) Part 231. APTA's petition seeks special approval, pursuant to 49 CFR §§ 238.21 and 238.230, for all newly manufactured passenger cars that are considered "cars of special construction" under 49 CFR § 231.18. This request was assigned Docket Number FRA-2007-0010.

Modern technology used in the construction of passenger cars does not lend itself readily to the application of the current 49 CFR requirements. Newly constructed passenger cars rarely fit neatly within the car categories created in Part 231. Most of the passenger cars currently being constructed are "cars of special construction" and subject to § 231.18. As a result, car designers are required to comply with Federal safety appliance standards by adapting the construction of safety appliance arrangements to multiple sections within Part 231. Given these conditions, newly constructed passenger cars are well-suited to take part in the special approval process established at § 238.21, where the alternative design standards meet the requirements contained at § 238.230(d).

After careful review of APTA's petition and the Federal Railroad Administration (FRA) Safety Appliance Task Force recommendations, FRA's Safety Board (Board) believes that granting the petition, subject to the conditions below, is in the public interest and consistent with railroad safety. The Board also finds that the petition, amended pursuant to the conditions below, meets the requirements set forth in § 238.230(d).

Accordingly, the Board approved APTA's petition for special approval, subject to the conditions listed below:

1) The concerns identified in the appendix attached to this letter must be revised and resubmitted by APTA prior to issuance of final approval for APTA SS-M-016-06 Standard for Safety Appliances for Rail Passenger Cars.

2) The effective date of APTA's minimum industry safety appliance standards for newly constructed passenger cars must be amended such that it corresponds with, but does not pre-date, FRA's final approval of the corrected APTA standard.

FRA reserves the right to amend or revoke this special approval upon receipt of information pertaining to the safety of rail operations or in the event of noncompliance with any condition of this special approval.

The relief granted by the conditional granting of the petition does not excuse compliance with any other Federal safety requirement. In any future correspondence regarding this petition, please refer to Docket Number FRA-2007-0010.

Sincerely,

Grady C. Cothen, Jr.
Deputy Associate Administrator
for Safety Standards and Program Development

Appendix

Recommended Changes

1) **Section 1.1**
   a) This section indicates that the new standard, if adopted by the FRA, will apply to new passenger cars built on or after January 1, 2008. This should be changed such that the effective date corresponds to, but does not pre-date, the date of FRA's final approval.

   b) FRA is also concerned that this section does not address whether the special approval process will be used for re-built or overhauled cars. FRA recommends adding a statement to indicate whether re-built or overhauled cars will continue to be subject to the existing safety appliance standards.

2) **Section 3.1.9**
   This section defines a fastener locking device as "A device applied to a fastener to prevent the fastener from loosening." This vague description could cover a multitude of devices. For example, using a spring washer or lock washer (see Section 3.1.20) may meet this definition initially, but may prove to be unreliable over time. APTA needs to define fastener locking devices in a manner that is consistent with FRA Technical Bulletin MP&E 98-14.

3) **Section 3.1.20**
   a) This section includes "Self-locking nuts or lock washers" and "other locking devices with a minimum design prevailing-off torque (for the first removal) of 22 in. lb. (2.5 N-m)." Currently, FRA does not allow the use of such devices under FRA Technical Bulletin MP&E 98-14. FRA recommends that those devices that are not in compliance with FRA Technical Bulletin MP&E 98-14 be removed from the standard.

   b) Also, the next to the last paragraph of this section should require that all specialty or proprietary locking devices, rivets, or bolts be installed in a manner that is consistent with FRA Technical Bulletin MP&E 98-14.

4) **Section 4.3**
   This section states "To allow for mill tolerances, actual sizes of components (i.e. material thickness, diameter, etc.) may be 5% below the normal sizes." FRA requests that APTA provide clarification with respect to the types of appliances that this section applies to as well as its applicability to minimum component sizes and minimum clearances.

better define carbody structures to ensure that such structures can adequately support those safety appliances attached thereto.

6) **Section 5**
FRA requests that APTA review this entire section to ensure that adequate information is provided to clarify the placement of safety appliances. Where applicable, the standard should reference the spatial relationship of one safety appliance to another (see Sections 5.9.4 and 5.10.4), include minimum measurements outboard from the centerline of the car to the side of the car, and reference the height above the top of the rail (see Section 5.7.4).

7) **Section 5.1.1**
This section describes the general requirements for the operation of a handbrake or parking brake; however, it does not address the requirement that the handbrake or parking brake be safely operated while the passenger car is in motion. This is a requirement of every car type listed in 49 CFR part 231 and should be included in the APTA Standard.

8) **Section 5.2.4(c)**
This section states "Steps exceeding 18 inches (457 mm) in depth shall be transversely braced or equivalent." APTA fails to provide a justification for eliminating the additional tread on sill steps exceeding 18 inches in depth, as presently required by 49 CFR §231.14(b)(4)(i). See "Comparison of APTA SS-M-016-06 to 49 CFR 231 & 238." FRA requests that this section be changed to read "Steps exceeding 18 inches (457 mm) in depth shall have an additional tread and be laterally braced." This change will be consistent with the current regulation.

9) **Section 5.3.1**
This section reads "At least one side door step per car side is required on cars that do not have a minimum of one entrance per car side with the lowest step at a height of 24 inches (610 mm) above top of rail (ATR) or less." This language is vague and APTA fails to provide a sufficient rationale for deviating from 49 CFR §231.14(f)(1). See "Comparison of APTA SS-M-016-06 to 49 CFR 231 & 238." FRA requests that APTA clarify this section with respect to the placement of side door steps and provide an adequate justification if it intends to deviate from the regulation.

10) **Section 5.3.3**
APTA fails to provide adequate justification for the change from the 8 inch to the 6 inch clear depth on side-door steps, as presently required by 49 CFR §231.14(f)(2). See "Comparison of APTA SS-M-016-06 to 49 CFR 231 & 238." APTA should provide an adequate justification if it intends to deviate from the regulation.

11) **Section 5.4.4(c)**
This section states "When one horizontal handhold is used, it shall be 54 to 56 inches (1,372 to 1,423 mm) ATR. See Figure 10." This is a deviation from the current regulation listed in 49 CFR §231.14(c)(3)(i). APTA should provide an ergonomic or other safety justification for deviating from the Federal standard.

12) Section 5.5.4(c)

This section is ambiguous. FRA recommends wording the section as follows: "The side door handhold shall be located outside of the side door opening and the side door handhold shall be located no more than 6 inches (152 mm) from the vertical inside face of the door opening."

13) Section 5.5.4(d)

a) This section states "On cab cars with non-passenger side entrances, two vertical side door handholds shall be installed, one on each side of the door, to continue to a point at least 58 inches (1,473 mm) above the cab floor at the door entrance. If the length of the handhold exceeds 60 inches (1,524 mm), it shall be securely fastened with two fasteners at each end." FRA is unclear with respect to the identification of the reference point for installing the handholds on each side of the door and believes a figure showing this location would be helpful.

b) If APTA intends to allow vertical handholds to exceed 60 inches in length, then the standard should provide a minimum diameter or thickness to support such a length and eliminate deflection.

c) Additionally, FRA requests that APTA clarify the car types applicable to this section.

14) Section 5.6.1

This section notes "Except as provided in Section 6, on cars with passenger entrances with the lowest step at a height of 24 inches ATR or less to be used in lieu of sill steps, crew handholds shall be applied" This section appears to conflict with section 5.2.4(b). FRA requests clarification.

15) Section 5.7.4

a) This section refers to figure 17 and identifies the placement of end handholds. FRA requests that APTA provide additional information such as the height above the top of the rail, height from the center line of a coupler or reference a relationship to another safety appliance such as the side handhold.

b) Additionally, APTA fails to provide a justification for the change from the 1 inch limit on projection allowed by 49 CFR §231.12(c)(2)(ii). See "Comparison of APTA SS-M-016-06 to 49 CFR 231 & 238."

16) Section 5.9.4(g)

This section refers to the assembly and securement of railing and stile assemblies. The section does not contain a requirement to sleeve jointed pipes as referenced in FRA Technical Bulletin MP&E 00-06. FRA recommends adding this requirement in this section or adding a similar note under Section 3 or 4.

17) **Section 5.9.4(h)**
This section details the requirements for operating platforms and handrails for a shortened wall and refers to figure 19. FRA is concerned that this configuration is in conflict with the requirements of sections 5.6.3 and 5.6.4 and requests clarification.

18) **Section 6**
This section refers to elective safety appliances and requires them to comply with section 5.10. FRA believes the correct section is 5.11 and should be changed accordingly.

19) **Section 7**
a) This section opens by stating "The railroad and the carbuilder may use the checklist in Annex A to verify that all the requirements of this standard have been addressed." While Annex A is a tool that is useful in meeting the standard, it should not be the only method used to verify the compliance of this standard. FRA recommends changing this statement to read "The railroad and the carbuilder may use the checklist in Annex A as a tool to assist in verifying the requirements of this standard have been addressed."

b) Additionally, the fourth paragraph of section 7 notes "Previous sample car inspections can be applied to new orders of the same design if there are no changes to the safety appliances. However, FRA and Transport Canada will require submittal of the safety appliance arrangement drawings for that order with reference to the previous sample car inspection." FRA recommends including a note in this section that, because of past experiences, "FRA and Transport Canada may perform random inspections and re-inspections of passenger cars at railroads and carbuilder locations."

c) FRA notes that the FRA Headquarters has relocated since the APTA Standard was received by the FRA. APTA needs to update the address to 1200 New Jersey Avenue S.E., Washington, D.C. 20590.

Ergonomic Items

1) **Section 5.2.4(e)**
As described in Figure 7, an employee could ride a car with his/her foot in a sill step inboard 4 inches from the outside edge of the car. This would place the outside edge of the sill step 21 inches ATR and 8 inches below the 4-inch inset distance. Anthropometrically a person's shin would clear the front edge of the car but, no additional distance should be added to the inboard measurement. An additional inset distance, greater than 4 inches, would make it difficult for employees to ride a car for a prolonged distance.

2) **Section 5.3.4(b)**
It is appreciated that the first statement of this section describes the goal of having the sill step as close to the top of rail as possible. In keeping with that thought, FRA recommends placing the sill step at 20 inches rather than 22 inches, which would make it easier for employees to board the sill step.

3) **Section 5.4.4(b)**
A minimum height, as part of a range, should be added for the lower handhold, recommended at 43 inches ATR, just above the belly button of a 95th percentile male when measured from the top of the tie. While this body position is not optimal for the 95th percentile male it is workable and provides a better leverage for the 5th percentile female.

4) **Sections 5.4.4(b) and 5.4.4(e)**
These sections currently hold the lower handhold at a maximum of 54 inches ATR. While this height will accommodate a 5th percentile female, FRA recommends placing the lower handhold at a maximum of 51 inches ATR, which will increase the arm strength that can be applied by a 5th percentile female and allow a person of that stature to board a car if a drop in ballast height would occur below the top of tie.

5) **Inset safety appliances with regard to the body of the railcar**
There is a concern that a worker could step down to the ground from a moving car and be struck by part of the same car or the next car moving toward the worker. A 1st percentile female for the horizontal measurement and a 99th percentile male vertical measurement were used as conservative parameters for clearance. These will insure that the small person will be clear of the car as the car side passes by and that the tall person will not hit his/her head on a low load.

The figure below is representative of the posture assumed by individuals getting off equipment.

The figure depicts a body position at its maximum height from the top of rail (24 inches) which will place the person higher and closer to the car side. The body position above shows a 1st percentile female with a horizontal distance from the ladder of approximately 18 inches. This is approximated because it could be less or more depending on the actual body position. FRA's Research and Development Division (RDV) noted that many engineering designs employ a safety margin to lessen the likelihood of failure. In most cases a factor of 2 is applied. In the present instance, that would reduce the acceptable inboard distance from 18 inches to 9 inches.

The safety margin could help to insure that once the employee has fully contacted the ground, all parts of the body would have cleared nine inches before a piece of equipment occupied the same space. When getting off moving equipment, the motion of the car transfers momentum to the employee so clearing nine inches is a safe margin.

According to the U.S. Army NATICK anthropometric tables, a 99th percentile male is 75 inches in height. Subtracting 9 inches for the height of the rail, FRA recommends that the protrusion of the car should be no lower than 66 inches ATR.

This point in space then is 66 inches from top of rail and 9 inches in from the clearance diagram.

AMERICAN PUBLIC TRANSPORTATION ASSOCIATION

September 4, 2007

Mr. Grady Cothen
Deputy Associate Administrator for Safety
Federal Railroad Administration
1120 Vermont Avenue, N.W.
Washington, DC 20005

Dear Mr. Cothen:

On October 19, 2006, the Federal Railroad Administration (FRA) published a final rule in the Federal Register entitled *Passenger Equipment Safety Standards; Miscellaneous Amendments and Attachment of Safety Appliances on Passenger Equipment* (RIN 2130-AB67). This final rule expanded the subject matter to which the special approval procedures contained in 49 CFR 238.21 may be applied to include passenger equipment safety appliances. Section IV, Subsection D of the preamble to this final rule discusses a request made by FRA to the American Public Transportation Association (APTA) for APTA to determine the feasibility of developing an industry safety appliance standard for newly manufactured passenger equipment. The last paragraph of Section IV, Subsection D of this preamble states that any such industry standard resulting will need to be submitted to and approved by FRA pursuant to the special approval procedures contained in 49 CFR 238.21.

In January 2006, the APTA Passenger Rail Equipment Safety Standards (PRESS) Mechanical Committee first met to undertake the development of an industry safety appliance standard for passenger cars. The committee met several times with full participation by FRA and Transport Canada and with limited participation by rail labor organizations to debate and reach consensus on the provisions of the standard. While the participation by rail labor was limited (by their choice), the practical input received from labor proved invaluable.

At the request of and with assistance from FRA, the Committee was able to recruit the participation of a freight railroad ergonomics professional. Many of the decisions reached by the committee were the result of recommendations made by this ergonomics professional.

The resulting standard has completed the PRESS approval process. The Commuter Rail CEO Committee unanimously authorized it for implementation. The final standard is now posted on the APTA web site where it can be downloaded without cost for use in the passenger railroad industry.

APTA is now in a position to petition FRA in accordance with the procedures contained in 49 CFR 238.21, Special Approval Procedure, to consider all newly manufactured passenger cars to be cars of special construction under 49 CFR 231.18 and to approve APTA's standard as an alternate means to comply with 49 CFR 231.18.

Enclosed with this letter is a copy of the final standard, a table that compares the standard with the current safety appliance regulations contained in the CFR and drawings requested by FRA (referred to as plates by FRA) that show typical installations of safety appliances in accordance with the standard. The Annex to the standard contains an inspection check list that railroads will require car builders to perform as a final quality control step to check the design and installation of safety appliances on newly manufactured passenger cars. This check list mirrors the FRA's sample car inspection procedures for safety appliances.

APTA believes Docket No. FRA-2005-23080 contains all the technical information that FRA will need to support a decision on this petition. In addition, FRA has all the meeting minutes and other meeting materials distributed from all the PRESS Mechanical Committee meetings held to debate and reach consensus on the final standard.

The primary person to be contacted with regard to this petition is Thomas Peacock, Director of Operations and Technical Services, American Public Transportation Association, 1666 K Street, N.W., Washington, D.C., 20006. Mr. Peacock can be contacted by telephone at 202 496-4805 or by e-mail at tpeacock@apta.com.

APTA has sent a copy of this petition to the following railroad labor representatives:

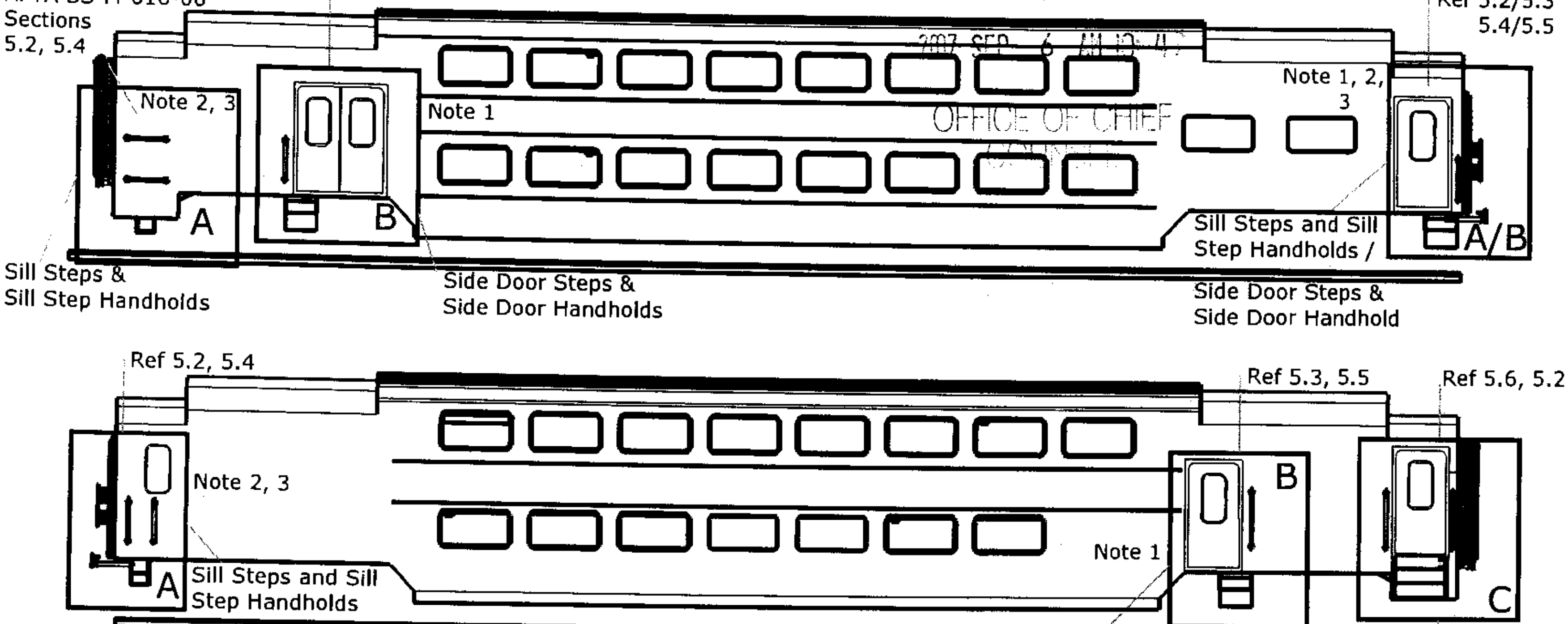
Mr. Marvin Napier
Mr. Rich Johnson
Mr. Thomas Pontillo
Mr. David Brooks
Mr. James Stem

Your's truly,

Thomas Peacock

Thomas Peacock
Director Operations and Technical Services

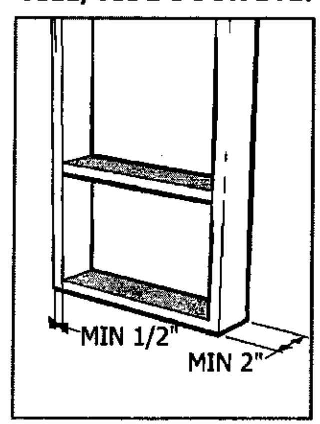
TP/dw



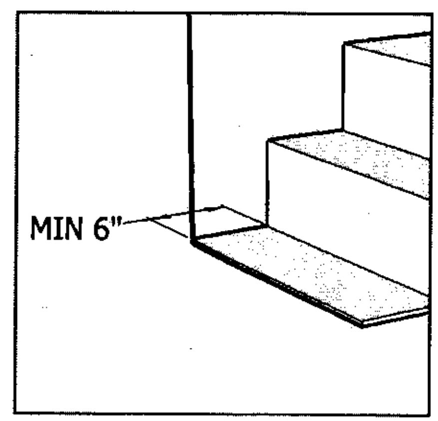
Notes:

1) At least one side door step per car side is required on cars that do not have a minimum of one entrance per car side with the lowest step at a height of 24 inches above the rail or less.
2) Each car shall have a sill step applied at each corner of the car where no useable passenger step is available.
3) Sill step handholds to be in one of five configurations:
   Two horizontal handholds **(A-1)**
   One horizontal handhold **(A-2)**
   One horizontal and one vertical handhold **(A-4)**
   One vertical handhold **(A-5)**
   Two vertical handholds **(A-3)**

SILL/SIDE DOOR STEP



PASSENGER STEPS



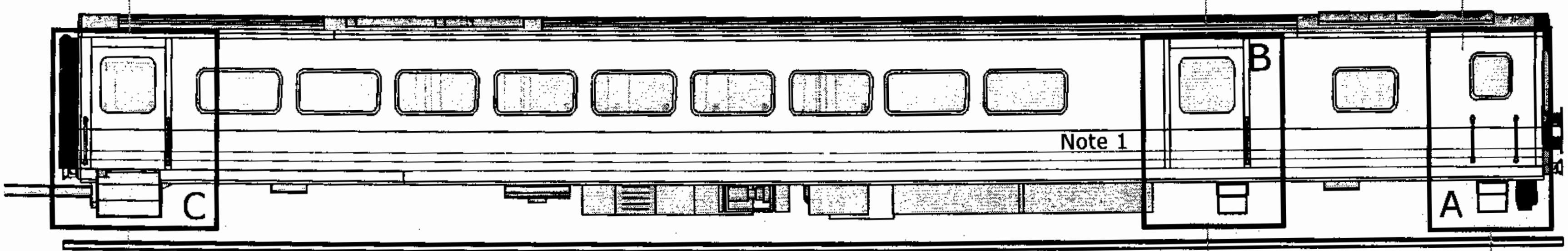
STV

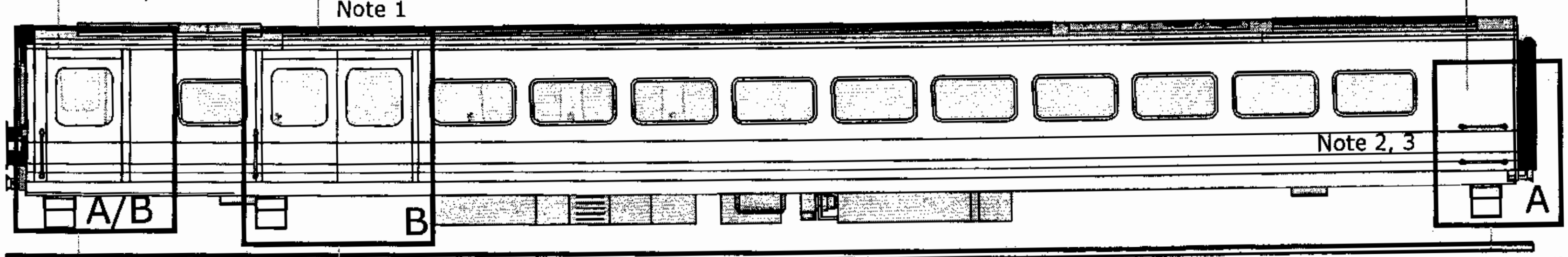
drawn by:
Matthew Bertrand
08/20/2007

APTA

Overview
Safety Appliances for Rail Passenger Cars
American Public Transportation Association

1





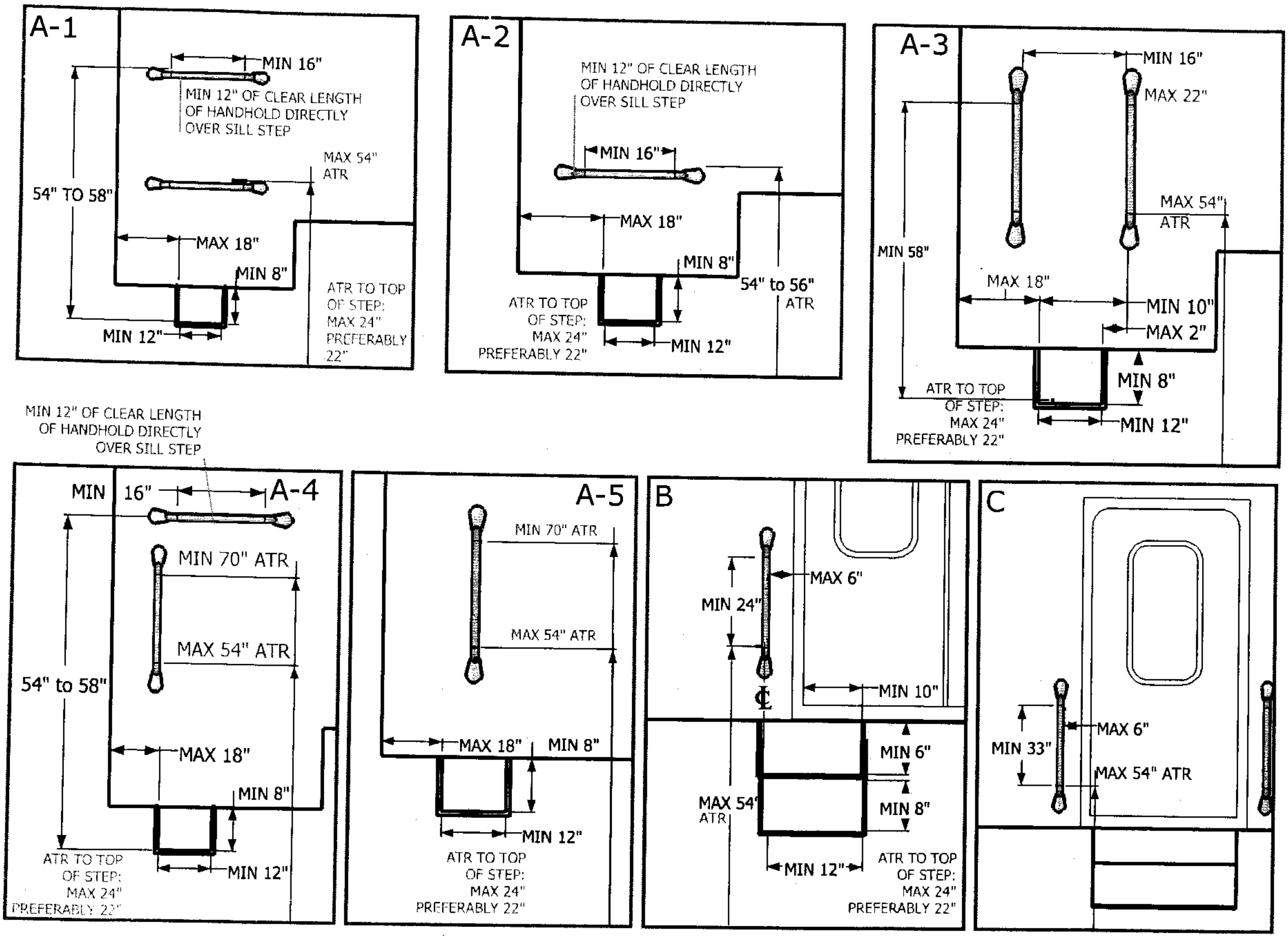
STV

drawn by:
Matthew Bertrand
08/20/2007

APTA

Overview - 2
Safety Appliances for Rail Passenger Cars
American Public Transportation Association

2



STV

drawn by:
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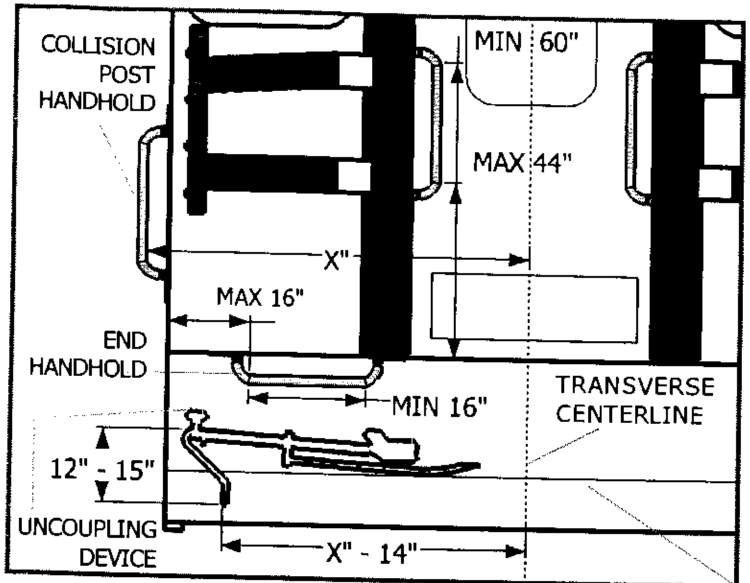
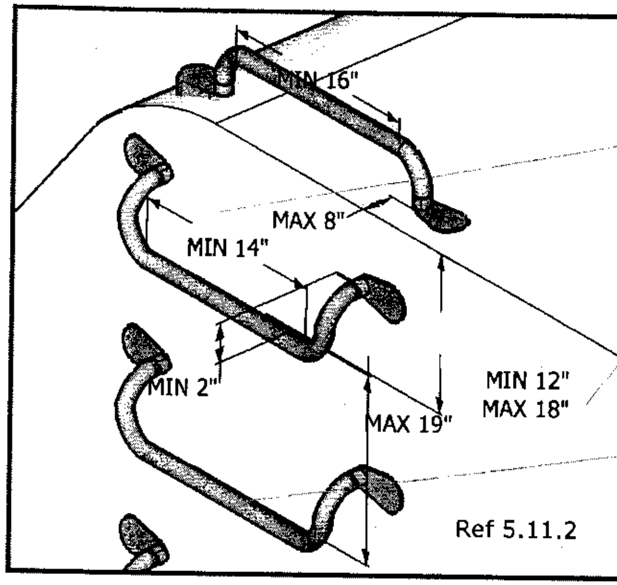
08/20/2007

APTA

Detail
Safety Appliances for Rail Passenger Cars
American Public Transportation Association

3





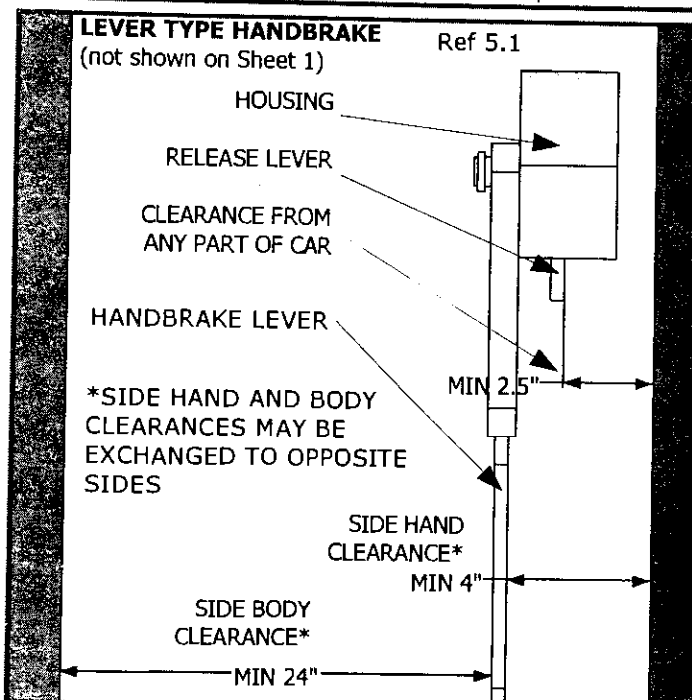
ROOF HANDHOLD

MINIMUM USABLE LENGTH:
14" FOR END LADDERS
16" FOR SIDE LADDERS

SPACING TOLERANCE:
UNIFORM WITHIN 2"

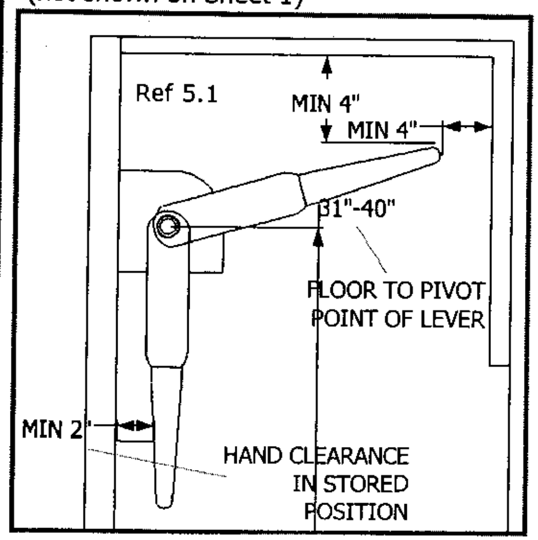
TREAD SIZE:
Rectangular cross-section:
MIN 2" wide, 1/2" thick
Circular cross-section:
MIN 5/8" diameter

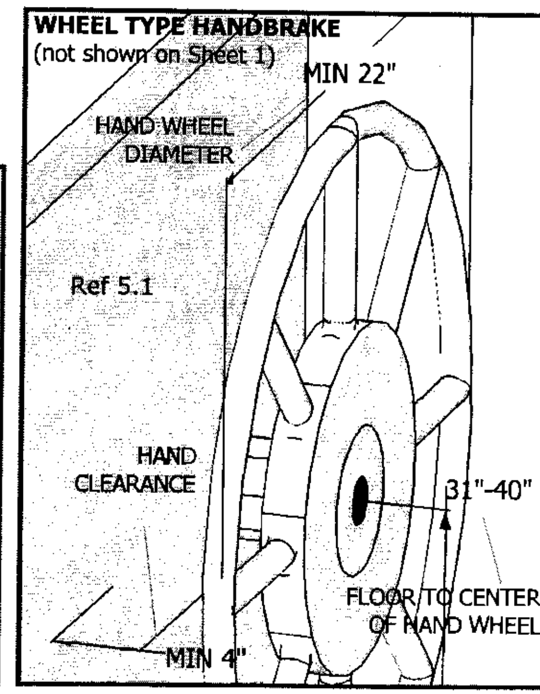
MIN TREAD CLEARANCE 2"



Reference:
APTA SS-M-016-06
Sections 5.7, 5.8, 5.10

LEVER TYPE HANDBRAKE
(not shown on Sheet 1)





STV

drawn by:
Matthew Bertrand
08/20/2007

APTA

End Of Car Equipment
Safety Appliances for Rail Passenger Cars
American Public Transportation Association

4

16. APTA SS-M-016-06 Standard for Safety Appliances for Rail Passenger Cars

Approved May 18, 2007
APTA PRESS Task Force

Authorized June 2, 2007
APTA Commuter Rail Executive Committee

Abstract: This standard establishes requirements for safety appliance design, installation and maintenance for rail passenger cars.

Key Words: safety appliance, handbrake, sill step, side door step, sill step handhold, side door handhold, crew handhold, end handhold, collision post handhold, roof handhold, ladder, uncoupling device, attachment, handrail

Introduction

(This introduction is not part of the standard)

The American Public Transportation Association (APTA) undertook the development of this standard because the application of the Federal regulations contained in 49 CFR Part 231 governing safety appliances to modern passenger equipment has become difficult. 49 CFR 231 contains three different passenger car types in parts 231.12 (Passenger-train cars with wide vestibules), 231.13 (Passenger-train cars with open-end platforms) and 231.14 (Passenger-train cars with without end platforms). Modern equipment designs do not follow these specific car configurations. The passenger railroads have introduced multiple level cars, cars with center boarding, cab cars, etc. These new car types do not easily fit into the three types defined in the regulation. As a result, almost one-third of the passenger equipment in operation today contains one or more safety appliance features that are not in compliance with the way the Federal Railroad Administration interprets the requirements of 49 CFR Part 231.

APTA developed this standard to provide clarity in the design, fabrication and installation of safety appliances for modern designs of passenger cars. The standard clearly defines the function of each type of safety appliance and gives detailed requirements on the dimensions, material, location and manner of attachment. An annex of the standard includes a compliance check list that car builders can use as a quality control tool to ensure compliance with the standard.

APTA developed this standard using a consensus (defined as a 75% majority) process that included representatives of all the parties affected. APTA patterned the standard after the Association of American Railroads' (AAR) Standard AAR S-2044 covering freight car safety appliances. The AAR has petitioned FRA to incorporate the freight car safety appliance standard into the Federal regulations.

APTA intends similarly to petition the Federal Railroad Administration (FRA) and Transport Canada to incorporate this standard into the Federal regulations. APTA intends to approach the FRA to make sample car inspections of each new design of passenger car mandatory and to use the compliance check list contained in this standard as part of the basis for this sample car inspection. In the future, APTA believes these steps will greatly reduce the number of newly built passenger cars that do not comply with Federal safety appliance regulations.

The APTA working group that developed this safety appliance standard for passenger rail cars included an ergonomics professional. The ergonomics professional advised APTA that riding a sill step when holding on to a single handhold is difficult in some operating circumstances. As a result, the standard requires two handholds placed an ergonomically acceptable distance apart above each sill step on new cars.

This caused controversy because many car designs have doors near the corner of the car that would preclude the placement of the second handhold an ergonomically acceptable distance from the first handhold.

Some passenger railroads currently prohibit their employees from riding sill steps because they believe the employees are safer riding inside the car or walking beside the car during switching moves. APTA surveyed 18 passenger railroads; 16 of them either currently have operating rules that prohibit riding sill steps or strongly discourage riding sill steps and would be willing to implement such an operating practice.

As a result of this survey, APTA considered an option to eliminate sill steps if the railroad has in place an operating practice that prohibits their use. The best way to enforce this operating practice is to eliminate the sill step. Employees cannot use what is not there. This solves the door-near-the-corner-of-the-car design problem. If a railroad wishes to operate equipment of this design, that railroad must either ban riding the sill step or determine a way to install a second handhold above the sill step an ergonomically correct distance from the first handhold.

Neither the FRA, Transport Canada nor the rail labor representatives to the working group supported this APTA proposal to make sill steps an option on future passenger cars. As a result of this lack of support, APTA modified the proposal.

The standard now requires a sill step and two corresponding handholds an ergonomically correct distance apart for all new equipment. If a railroad wishes to procure new equipment designs where placement of two handholds above the sill step is not possible, that railroad may do so if it adopts an operating practice that prohibits riding that sill step.

This new requirement accomplishes two important things: 1) for new equipment, railroad employees are provided the extra safety of a second handhold, or they are not allowed to expose themselves to the danger of riding a sill step equipped with only one handhold; and 2) railroads can continue to purchase equipment designs with corner doors.

As with all compromises, the new requirement has a downside. A sill step with a single handhold must be provided even when the railroad bans riding the sill step. From a railroad's perspective, this does not make sense. But it gained the FRA, Transport Canada and labor support necessary for APTA to go forward. This compromise answers labor's concern over the interchange of equipment without sill steps between passenger railroads and overhauling such passenger cars in freight trains. Overall safety of railroad employees will increase with time as more cars with two handholds above sill steps enter the fleet.

Participants

The American Public Transportation Association greatly appreciates the contributions of the following individuals who provided the primary effort in the drafting of this *Standard for Safety Appliances for Rail Passenger Cars.*

Allen Bieber
Stephen Bonina
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Gordon Campbell
David Carter
Stephen Carullo
Ghislain Champire
George Chipko
Richard Conway
Joshua Coran
Craig Daly
Ralph Dolinger
Gary Fairbanks
Lawrence Fleischer
Andrew Frohn
Paul Furman
Randy Gnam
James Guseman
Tom Herrmann
Christopher Holliday
Paul Jamieson
John Janiszewski
Larry Kelterborn
Jeff Kovacs
Nancy Lessard
Peter Lloyd
Ken Mannen
James Michel
Marvin Napier
Ron Newman
George Payne
Carol Rose
Patrick Sheeran
Carlos Sosa
Richard Stegner
James Stoetzel
Harold Weisinger
Charles Whalen
Gary Widell

At the time this standard was completed, the Passenger Rail Equipment Safety Standards (PRESS) Mechanical Committee included the following members:

Dave Carter, Chair

Steven Abramopaulos
M. Andriani
Gordon Bachinsky
Jack Barnas
Ken Barnish
Al Bieber
George Binns
Brad Black
Rick Brilz
Chris Brockhoff
Dick Bruss
Dave Brooks
Mark Campbell
Gary Carr
John Casale
Al Cheren
George A. Chipko
Steve Chrismer
Roger Collen
Richard Conway
Steve Costanzo
Jack Coughlin
Tim Cumbie
Erik Curtis
Graham Curtis
Richard Curtis
Steve Dedmon
John M. Dermody
Greg Dvorchak
Ed Deitt
Magdy El-Sibaie
John Elkins
Dave Elliott
Owen Evans
Gary Fairbanks
Ronald L. Farrell
Andrew F. Farilla
Benoit Filion
Chuck Florian
Greg Gagarin
John Goliber
Jeff Gordon
Thomas Grant
Harry Haber
Kevin Heidrich
Francois Henri
Ken Hesser
Christopher Holliday
Paul E. Jamieson
James Jewell
Richard Johnson
Joe Kalousek
Joe Kahr
Bob Kells
Larry Kelterborn
Kevin Kesler
Paul Kezmarsky
Peter Klauser
Sunil Kondapalli
John P. Konrad
Susan Kristoff
Rick Laue
Nicolas Lessard
Jason Lipscomb
Cameron Lonsdale
Ben Lue
William Lydon
Susan Madigan
Dan Magnus
Eric Magel
Frank Maldari
George Manessis
Jean Major
John Mardente
James Martin
Brian Marquis
Keith McCarrick
Don Minini

Heiner Moehren
Donald Morrissey
Dak Murthy
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APTA SS-M-016-06
Standard for Safety Appliances for Rail Passenger Cars

1. Overview

1.1 Scope

This standard applies to new railroad passenger cars of all types, including baggage cars, with initial procurement contract awarded on or after January 1, 2008, for use on the general railroad system of the United States and Canada. This standard does not apply to non-passenger carrying locomotives.

In the event of discrepancy between the text of this standard and the illustrations, the text shall govern.

1.2 Purpose

The American Public Transportation Association (APTA) developed this standard to enhance the operational safety of new passenger cars by recognizing modern analytical techniques and manufacturing methods and to provide clarity and uniformity in the application of safety appliance regulations. APTA intends to petition the Federal Railroad Administration (FRA) and Transport Canada to incorporate this standard in total or by reference into the appropriate Rules and Regulations. If that happens, changes to existing contracts resulting in financial burdens caused by this standard should be handled through the established FRA and Transport Canada waiver/exemption processes.

2. References

2.1 References

This standard is to be used in conjunction with the following publications. When non-regulatory references are superseded by an approved revision, the revision shall apply for this standard and APTA will petition FRA and Transport Canada for a corresponding change in their rules and regulations.

49 CFR, Part 231, Railroad Safety Appliance Standards

49 CFR, Part 238, Rail Passenger Equipment Safety Standards

AAR S-2044, Requirements for Freight Car Safety Appliances

APTA SS-C&S-020-03, Standard for Passenger Rail Vehicle Structural Repair

APTA SS-I&M-007-98, Rev. 1, Standard for Passenger Car Exterior Periodic Inspection and Maintenance

APTA SS-M-006-98, Rev. 1, Standard for Parking Brakes for New Passenger Locomotives and Cars

AWS D1.1-06, Structural Welding Code – Steel

AWS D1.3-98, Structural Welding Code – Sheet Steel

AWS D1.6-99, Structural Welding Code – Stainless Steel

CSA W47.1-03, Certification of Companies for Fusion Welding of Steel

CSA W59-03, Welded Steel Construction (Metal Arc Welding)

Transport Canada's Passenger Car Inspection and Safety Rules

2.2 Coordinate System and Units of Measurement

The following figures show the coordinate system used in this standard. This coordinate system is used to be consistent with FRA and Association of American Railroads (AAR) terminology. Figure 1 shows coordinates in relation to safety appliances. Figure 2 shows coordinates in relation to the passenger car.

Vertical dimensions defined relative to the top of rail are to be based on new, empty car conditions.

Units of measurement used in this Standard are United States (U.S.) customary units. These are followed by their arithmetic equivalents in International System (SI) units, enclosed in parentheses. The first value stated shall be regarded as the requirement. The converted equivalent value may be approximate.

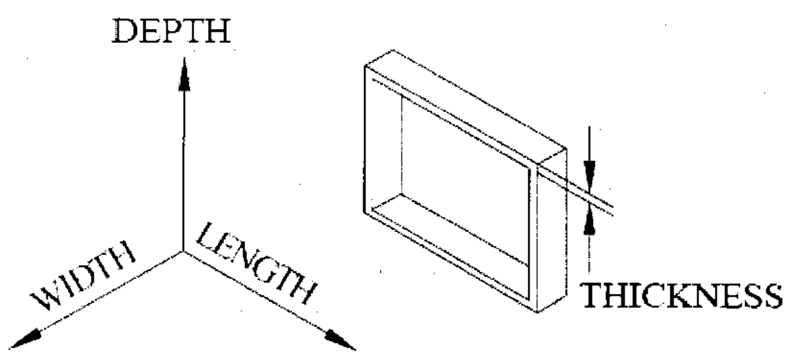

Figure 1 – Safety Appliance Coordinate System

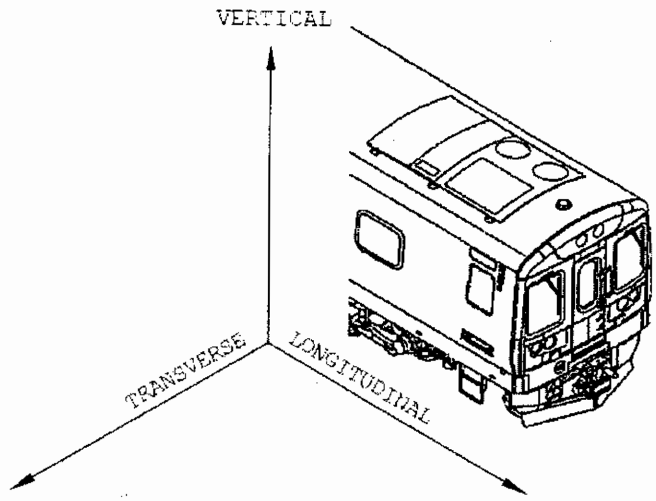

Figure 2 – Passenger Car Coordinate System

3. Definitions, Abbreviations, and Acronyms

3.1 Definitions

3.1.1 clear depth: As applied to step treads, is the distance measured vertically from the top surface of the tread to the closest obstruction anywhere within the specified minimum clear width and useable length. See Figure 3.

3.1.2 clear length: As applied to handholds, is that distance about which a minimum 2 inch (51 mm) hand clearance (from obstructions due to car design) exists in all directions around the handhold. The clear length of one portion of a handhold does not include handhold portions in other directions or bend radii connecting non-continuous portions of a handhold. Intermediate supports may be considered part of the clear length. Unless otherwise stated, limitations on handhold length apply to the clear length. See Figure 4.

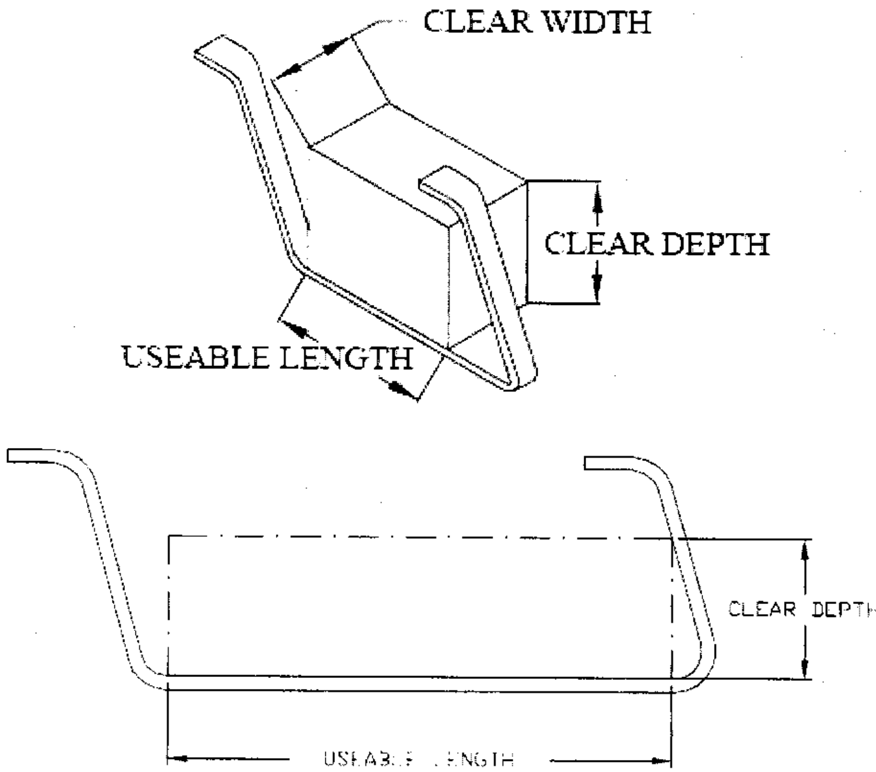

Figure 3 – Sill Step Length and Clearances

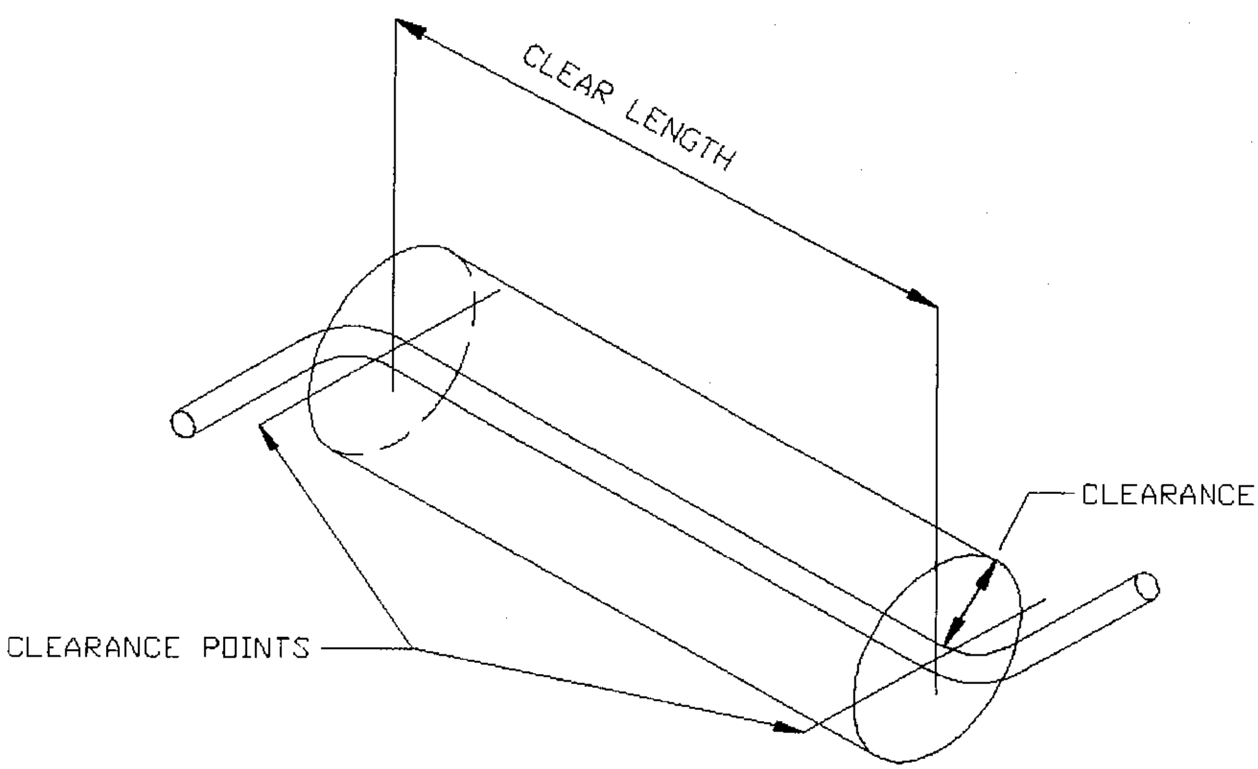

Figure 4 – Clear Length of Handholds

3.1.3 clear width: As applied to step treads, is the distance measured from the outboard surface of the tread to the closest inboard obstruction anywhere within the specified minimum clear depth and useable length. See Figure 3.

3.1.4 clearance points: As applied to handholds, are the ends of the clear length. See Figure 4.

3.1.5 collision post handhold: Handhold located at the end passageway of the vehicle to stabilize an employee when standing at the end of the car guiding reverse moves and to stabilize an employee when walking between cars.

3.1.6 continuous weld: completed weld without breaks betweens it ends a continuous weld need not be around the entire perimeter of the item welded to the car body as long as it is a single weld with no breaks.

3.1.7 crew handhold: Handhold used to assist an employee while entering or leaving a passenger entrance.

3.1.8 end handhold: Handhold located at the end of the vehicle to stabilize an employee when using the uncoupling device or as needed when connecting and disconnecting hoses and cables or when inspecting the vehicle.

3.1.9 fastener locking device: A device applied to a fastener to prevent the fastener from loosening.

3.1.10 handbrake: A brake that can be applied and released by hand to prevent movement of a rail car.

3.1.11 handrail: A rail serving as a support or guard on open platform cars to enclose the platform area and stabilize an employee standing on the open platform.

3.1.12 inboard: Towards the centerline of the car in either the transverse or longitudinal direction.

3.1.13 ladder: An arrangement of treads and/or handholds used for climbing to allow an employee to access equipment or perform a function that cannot be done from the ground.

3.1.14 longitudinal: Parallel to the centerline of track.

3.1.15 open platform car: A railcar with a non-enclosed section at the end of the car.

3.1.16 outboard: Away from the centerline of the car in either the transverse or longitudinal direction.

3.1.17 parking brake: A system that is applied to prevent a car from rolling due to gravity. This shall include systems referred to as handbrakes.

3.1.18 prevailing-off torque: The torque measured when the fastener is being removed when there is zero axial load in the assembly.

3.1.19 roof handhold: Handhold located on the roof to be gripped for support when performing maintenance or inspections on the roof.

3.1.20 securely fastened: Applied with steel bolts or cap screws not less than 1/2 inch (M12) diameter. The bolts or cap screws shall conform to one of the following specifications:

- Carbon/low alloy steel – SAE J429, Grade 5 (English units) or SAE J1199, Grade 9.8 (metric units)
- Stainless steel – ASTM F593, Groups 1-3, Condition CW1 (English units) or ASTM F738M, Grades A1-70, A2-70 or A4-70, Condition CW (metric units)

Nuts of corresponding strength and appropriate chemical composition shall be used.

The fasteners must be secured by one of the following methods:

- When the nuts are facing out, the nuts may be riveted over or chisel checked to 1/8 inch depth at two locations.
- If nuts are not riveted over, or for all cases where the fastener is threaded inward, securely fastened appliances shall include locking devices conforming with one of the following criteria:
    - Self locking nuts or lock washers.
    - Wedge-locking washers consisting of two symmetrically designed washers that have inclined ramps on the sides in mutual contact and non-slip contact surfaces on the sides in contact with the nut and workpiece. Similar washer and nut arrangements utilizing the same locking principles are also acceptable.
    - Other locking devices with minimum design prevailing-off torque (for the first removal) of 22 in.lb. (2.5 N-m).

Alternately, one-piece or two piece rivets or Huck bolts may be used.

All specialty or proprietary locking devices, rivets, or bolts shall be installed in accordance with the manufacturer's published instructions.

Fasteners used in securely fastened equipment shall not be re-used.

3.1.21 semi-permanently coupled: Coupled by means of a drawbar or other coupling mechanism that requires tools to perform the uncoupling operation. Coupling and uncoupling of each semi-permanently coupled unit in a train can be performed safely only while at a maintenance or shop location where employees can safely get under or between units.

3.1.22 side door handhold: Handhold located on the side of the car above a side door step.

3.1.23 side door step: Step or stirrup located on the side of the car to assist an employee in entering or leaving a side door entrance.

3.1.24 sill step: Step or stirrup located on the side, near the end of the car to allow an employee to ride on the side of the car during switching moves.

3.1.25 sill step handhold: Handhold located on the side of the car above a sill step.

3.1.26 transverse: Perpendicular to the centerline of the track in the horizontal plane.

3.1.27 uncoupling device: Mechanism used to uncouple cars without requiring an employee to go between cars.

3.1.28 useable length: As applied to sill steps, side door steps and step treads, is the straight length, not including bend radii, above which the specified minimum clear depth exists. Unless otherwise stated, limitations on the length of sill steps and step treads apply to the useable length. See Figure 3.

3.2 Abbreviations and Acronyms

AAR	Association of American Railroads
ATR	above top of rail
AWS	American Welding Society
CFR	Code of Federal Regulations
CWB	Canadian Welding Bureau
FRA	Federal Railroad Administration
kg	kilograms
lb	pounds
mm	millimeter
MPa	megapascal
psi	pounds per square inch
SAE	Society of Automotive Engineers
SI	International System of Units
U.S.	United States

4. Safety Appliances

4.1 General

Safety appliances applied to cars shall be designed, manufactured, installed and maintained in accordance with the requirements of this standard. Refer to the appropriate railroad's clearance diagram when designing safety appliances and their locations.

Note: APTA recommends that railroads and carbuilders consider designing to dimensions greater than the minimums and less than the maximums contained in this standard to allow for manufacturing tolerances and other minor deviations.

4.2 Purpose

A safety appliance aids railroad employees or contractors in performing their duties safely by providing a means to support and/or stabilize themselves while riding equipment, entering or leaving equipment, inspecting equipment, coupling/uncoupling equipment or setting handbrakes.

4.3 Materials and Processes

All sill steps, side door steps, ladders, handrails and handholds shall be made of steel with minimum yield strength of 25,000 psi (170 MPa). Stainless steel of equivalent strength may be used. Safety appliances may be cast, rolled, forged or made by any other process that provides the required strength.

To allow for standard mill tolerances, actual sizes of components (i.e. material thickness, diameter, etc.) may be 5% below the nominal sizes. Clearance dimensions are minimum dimensions (-0%).

4.4 Manner of Application

a) All safety appliances shall be securely fastened to the carbody structure.

b) Brackets or supports to which safety appliances are fastened are considered part of the carbody and are not required to be mechanically fastened to the piece of passenger equipment if all of the following are met:

   1) Except for any access required for attachment of the safety appliance, the weld is continuous around the perimeter of the surface of the bracket or support;

   2) The area of the weld is sufficient to ensure a minimum weld strength, based on yield, of three times the strength of the number of SAE Grade 2, 1/2 inch diameter (M12 Class 5.8) bolts that would be required for each attachment;

   3) The attachment is made with fillet welds at least 3/16 inch (5 mm) in size;

   4) The bracket or support is welded to a surface of the carbody that is at a minimum 3/16 inch (5 mm) sheet steel or is structurally reinforced to provide the equivalent strength and rigidity of 3/16 inch (5 mm) sheet steel;

   5) The weld takes into account the variable stress state of the carbody at the weld location;

   6) The weld is designed for infinite fatigue life in the application in which it will be placed;

   7) The weld is performed in accordance with the welding process and the quality control procedures contained in the current American Welding Society (AWS) Standard, the Canadian Welding Bureau (CWB) Standard or an equivalent nationally or internationally recognized welding standard;

   8) The weld is performed by an individual possessing the qualifications to be certified under the current AWS Standard, CWB Standard or any equivalent nationally or internationally recognized welding qualification standard;

   9) The weld is inspected by an individual qualified to determine that all welds are in conformance with the design drawings and the current AWS Standard, CWB Standard or any equivalent nationally or internationally recognized welding qualification standard; and,

   10) A written or electronic record of the inspection required in paragraph 9) of this section shall be preserved and shall be provided to the FRA or Transport Canada upon request. At a

minimum, this record shall include date, time, location, identification of the person performing the inspection and the qualifications of the person performing the inspection.

5. Safety Appliance Arrangement – General

5.1 Handbrake / Parking brake

5.1.1 General

Except as provided in Section 6, each car shall have a handbrake or parking brake that complies with APTA SS-M-006-98, Rev. 1, and that operates in harmony with the power brake equipment on the car. If a parking brake is used, it shall be capable of being set from each car, and each car shall be equipped with a means to release the parking brake manually.

5.1.2 Purpose/Function

The handbrake/parking brake is used to apply force mechanically to one or more brake shoes or pads on the car.

5.1.3 Location (Figures 5 and 6)

5.1.3.1 General – Handbrakes, Lever or Wheel Type

a) The handbrake as installed, whether applied or released, and in its stored position shall be located so as to not restrict passenger flow through any passageway.

b) The handbrake shall be located so it can be safely operated while the car is in motion.

c) A handhold shall be provided to stabilize an employee when using the handbrake.

d) The center point of the wheel or the pivot point of the lever used to apply the handbrake shall be located 31 to 40 inches (787 to 1016 mm) above the floor.

5.1.3.2 Handbrake – Lever Type

a) Any handbrake handle retention mechanism shall not interfere with the normal grip position of the lever.

b) The handbrake lever and release lever shall have a minimum 2 inch (51 mm) hand clearance in the stored position. The handbrake lever shall have a minimum 24 inch (610 mm) body clearance on one side of the lever and a minimum 4 inch (102 mm) hand clearance on the opposite side and end in the operating position.

c) The clearance between the grip portion of the release lever, if used, and any part of the car shall be no less than 2.5 inches (64 mm).

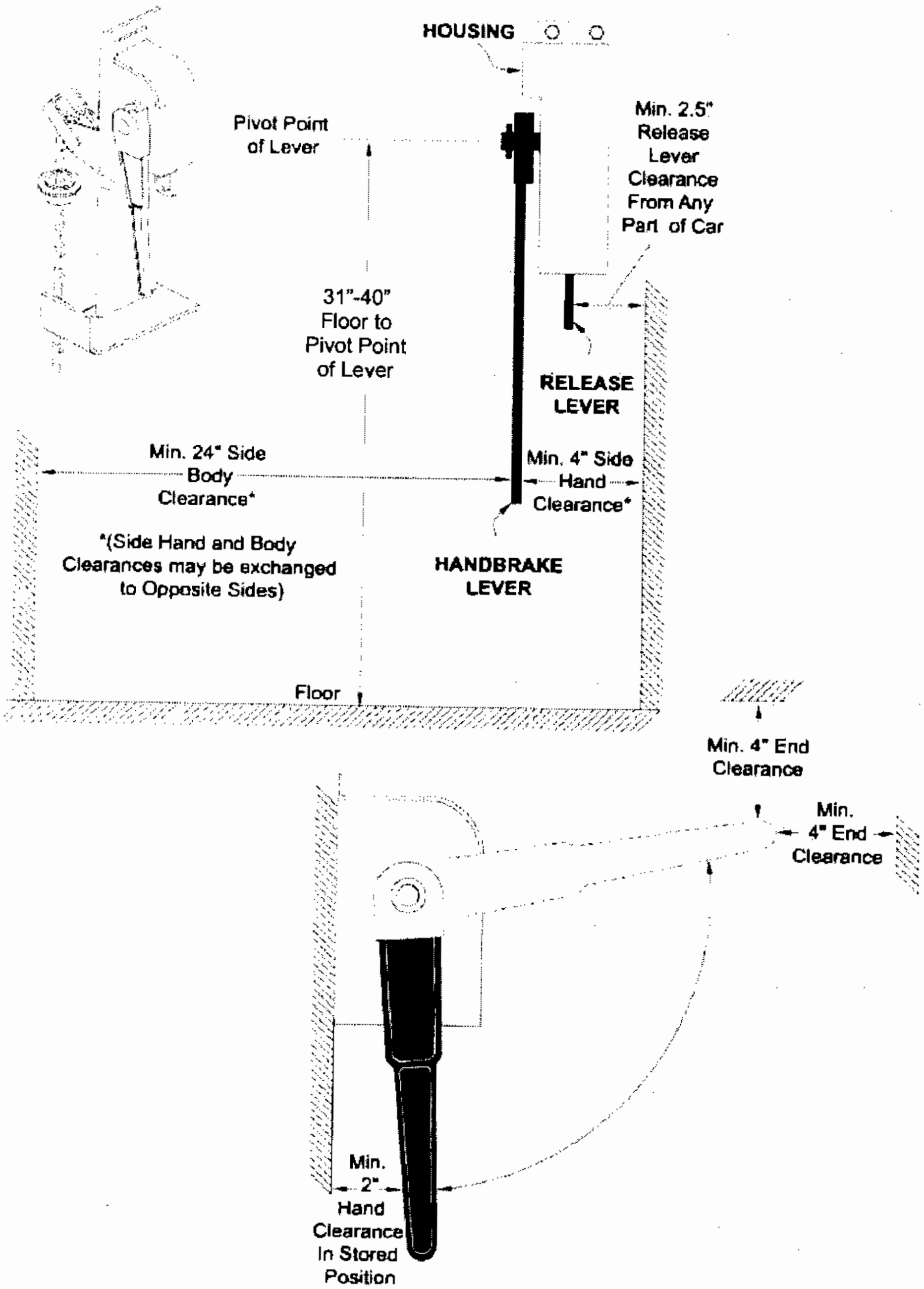

Figure 5 - Lever Type Handbrake

5.1.3.3 Handbrake – Wheel Type

a) The wheel type handbrake shall have a minimum 4 inch (102 mm) hand clearance.

b) The wheel diameter shall be at least 22 inches (559 mm).

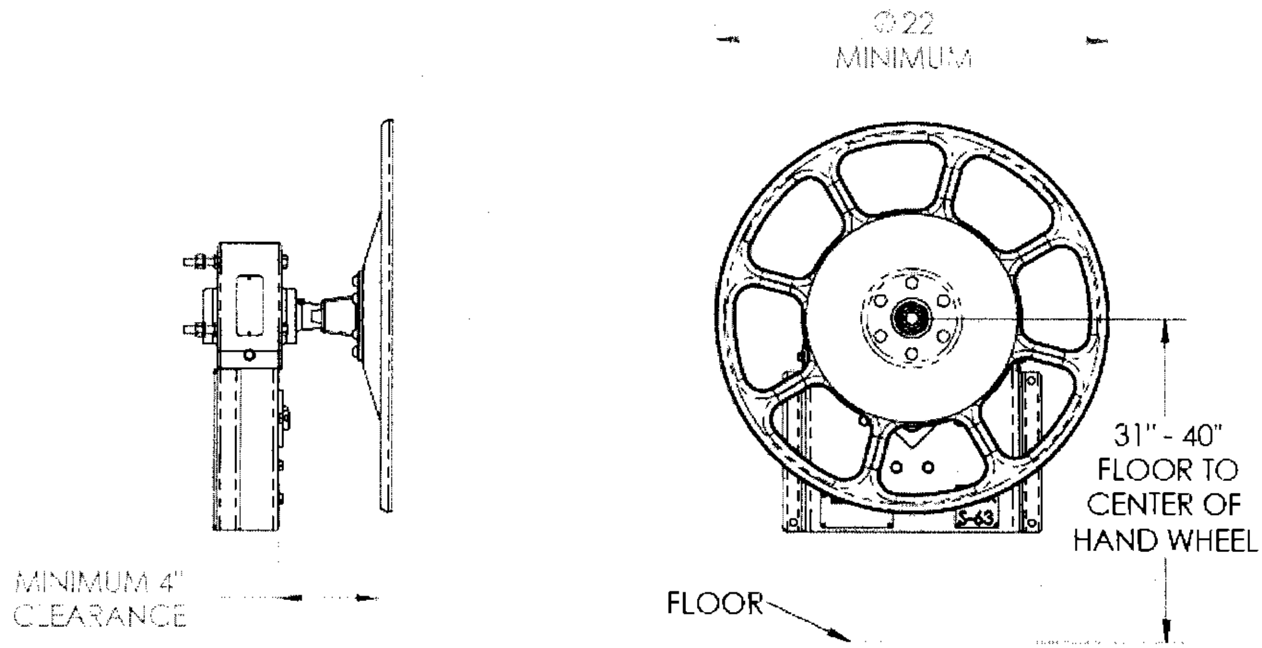

Figure 6 – Wheel Type Handbrake

5.1.3.4 Parking Brake

The parking brake manual release lever shall have a minimum 2 inch (51 mm) hand clearance.

5.1.4 Manner of Application – Details

The handbrake housing must be securely fastened. Bolts used for mounting the handbrake shall be designed to resist the maximum chain force with a minimum factor of safety of 2. The maximum chain force is that developed by the handbrake mechanism when a 125 lb. (556 Newton) force is applied 3 inches (76 mm) in from the end of the application lever, typically 20 to 24 inches (508 to 610 mm) long, or on the rim of a handbrake wheel unless the design of the mechanism restricts the applied force to a lower value.

Hand brake mounting brackets are to be securely fastened unless the use of mechanical fasteners is not feasible for the particular application. Bell crank mounting brackets, sheave wheel mounting brackets, brake rod supports and guides, and chain supports and guides are not considered safety appliances, and hence are not subject to the manner of application requirements in this standard. See Figures 5 and 6 for typical handbrake applications.

5.2 Sill Steps

5.2.1 General

Except as provided in Section 6, each car shall have a sill step applied at each corner of the car where no useable passenger step is available.

5.2.2 Purpose/Function

Sill steps allow an employee to ride on the side, near the end of the car during switching moves.

5.2.3 Dimensions

a) The minimum useable length of tread shall be not less than 12 inches (305 mm).

b) Sill steps shall be no less than 1/2 inch (13 mm) thick and no less than 2 inches (51 mm) wide. Alternate material sections may be used if they maintain the equivalent strength and rigidity of a 1/2 inch (13 mm) thick by 2 inch (51 mm) width step. Tread width shall be maintained at a 2 inch (51 mm) minimum.

c) The clear depth above the entire useable length of the sill step tread shall be no less than 8 inches (203 mm) and the clear width of all sill step treads shall be no less than 6 inches (152 mm) with the trucks rotated to simulate the maximum curvature specified for the uncoupled car.

d) To account for minor deviations, the application of sill steps shall be such that a box with the following dimensions can pass through the opening above the sill step to the point where the box is flush with the outer edge of the step. See Figure 3.

	Box Length	**Box Depth**	**Box Width**
Sill step	10 inches (254 mm)	8 inches (203 mm)	6 inches (152 mm)

5.2.4 Location (Figures 7 and 9-13)

a) One sill step shall be applied at each corner of the car. A passenger step may be used in lieu of a sill step if it meets the clear depth, clear width, useable length and location requirements for a sill step.

b) The outboard end of the useable length of the sill step shall be not more than 18 inches (457 mm) in the longitudinal direction from the corner of the car. For cars without well-defined corners, the intent is for the sill step to be positioned for the employee to have an unobstructed view of the track ahead. The sill step shall be placed so the employee has a clear view in both longitudinal directions and shall be placed outside of the gauge of the track.

c) Steps exceeding 18 inches (457 mm) in depth shall be transversely braced or equivalent.

d) The design goal is to have the tread of the sill step as close to the top of rail as the clearance diagram permits. The sill step tread shall be not more than 24 inches (610 mm), preferably not more than 22 inches (560 mm), above the top of rail.

e) The design goal is to have the outside edge of the tread of the sill step as close to being flush with the side of the car as the clearance diagram permits. To align sill step width with respect to handholds, in the transverse direction, the outside edge of any sill step tread shall not be more than 4 inches (102 mm) inboard or outboard of the inside surface of the lowest adjacent side handhold clear length. In addition, the outside edge of any sill step tread shall be no more than 2 inches (51 mm) inboard of any car structure below the lowest adjacent side handhold in the area from the inboard clearance point of the handhold to the outboard vertical leg of the sill step. If the clearance diagram of the railroad does not allow this 2 inch requirement to be achieved, up to 4 inches (102 mm) may be allowed provided the sill step tread is no more than 21 inches above the top of rail.

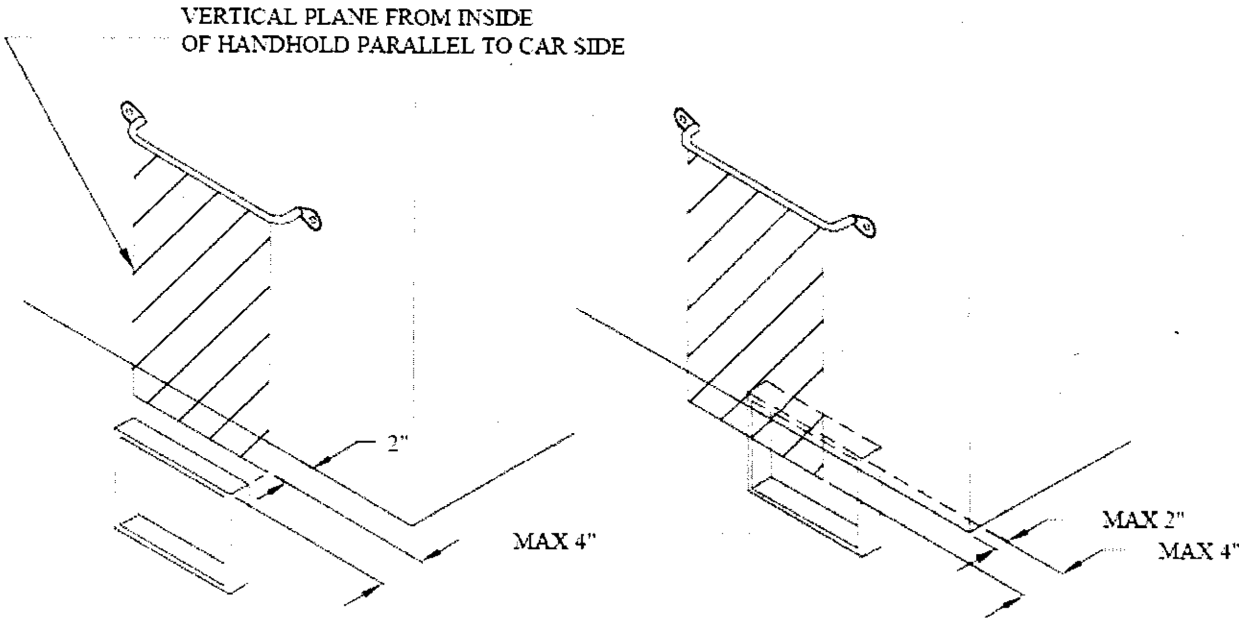

Figure 7 – View of Sill Step in Transverse Direction

5.3 Side Door Steps

5.3.1 General

At least one side door step per car side is required on cars that do not have a minimum of one entrance per car side with the lowest step at a height of 24 inches (610 mm) above top of rail (ATR) or less.

5.3.2 Purpose/Function

Side door steps assist an employee in entering or leaving a side door entrance with the lowest step at a height greater than 24 inches (610 mm) ATR.

5.3.3 Dimensions

a) The minimum useable length of tread shall be 12 inches (305 mm).

b) Side door step treads shall be no less than 1/2 inch (13 mm) thick and no less than 2 inches (51 mm) wide. Alternate material sections may be used if they maintain the equivalent strength and rigidity of a 1/2 inch (13 mm) thick by 2 inch (51 mm) width step. Tread width shall be maintained at a 2 inch (51 mm) minimum.

c) Steps exceeding 18 inches (457 mm) in depth shall have an additional tread and be transversely braced or equivalent.

d) The clear depth above the entire useable length of the lowest side door step tread shall be no less than 8 inches (203 mm) and the clear depth above the entire useable length of all other side door step treads shall be no less than 6 inches (152 mm). The clear width of all side door step treads shall be no less than 6 inches (152 mm) with the trucks rotated to simulate the maximum curvature specified for the uncoupled car.

e) To account for minor deviations, the application of side door steps shall be such that a box with the following dimensions can pass through the opening above the side door step to the point where the box is flush with the outer edge of the step. See Figure 3.

	Box Length	**Box Depth**	**Box Width**
Lowest side door step	10 inches (254 mm)	8 inches (203 mm)	6 inches (152 mm)
All side door steps, except lowest	10 inches (254 mm)	6 inches (152 mm)	6 inches (152 mm)

5.3.4 Location (Figure 8)

a) For side door steps that extend beyond the side door opening in the longitudinal direction, the inside face of the leg of the side door step that is located under the door opening shall be at least 10 inches (254 mm) in the longitudinal direction from the vertical inside face of the door opening. The inside face of the opposite leg of the side door step shall be located on the centerline of the side door handhold or extend beyond it.

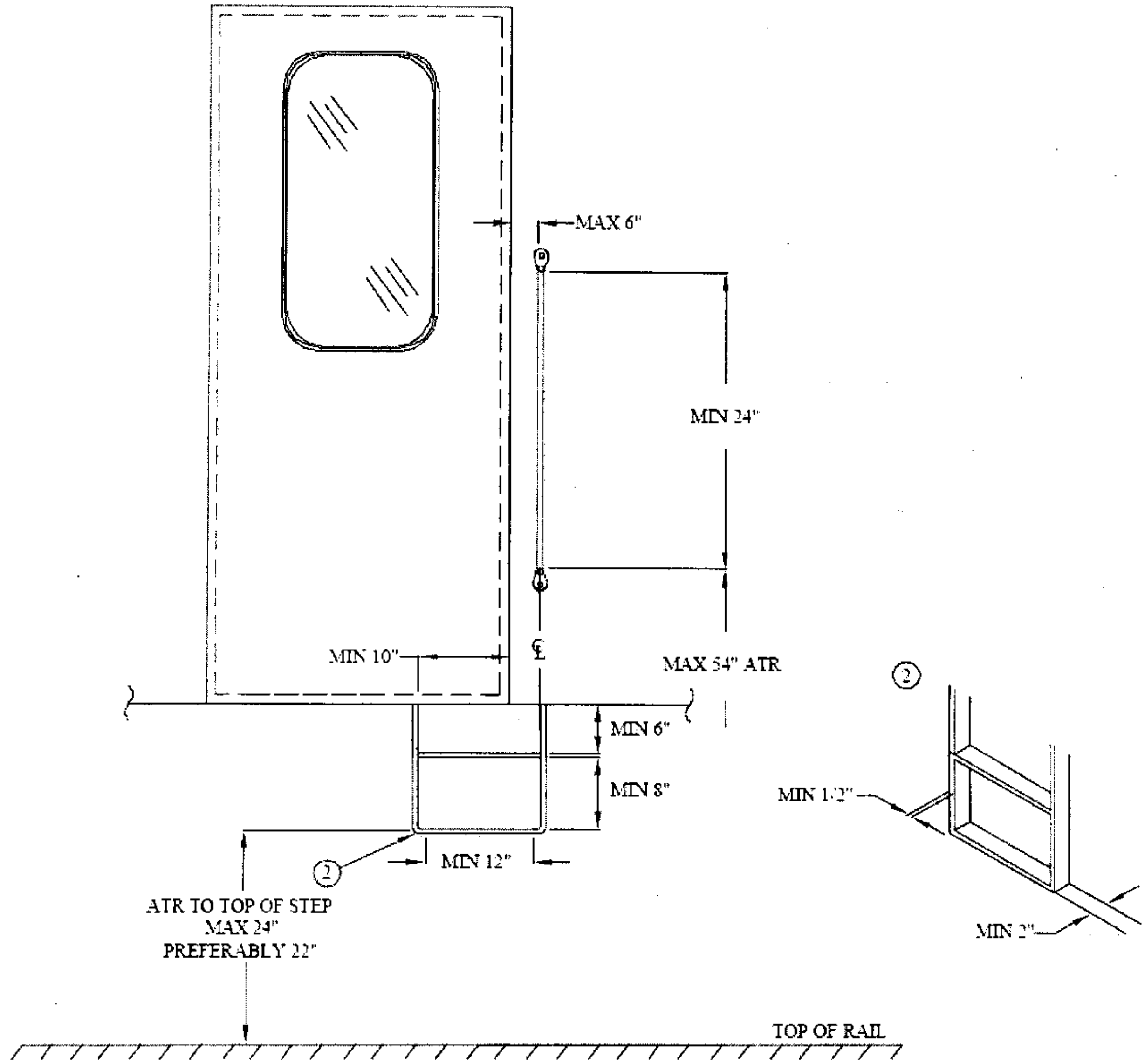

Figure 8 - Side Door Steps and Vertical Handholds at Non-End of Car with High-Level Entrance

b) The design goal is to have the tread of the side door step as close to the top of rail as the clearance diagram permits. The lowest tread shall be not more than 24 inches (610 mm), preferably not more than 22 inches (560 mm), above the top of rail.

c) The design goal is to have the outside edge of the tread of the side door step as close to being flush with the side of the car as the clearance diagram permits. To align side door step width with respect to handholds, in the transverse direction, the outside edge of any step tread shall not be more than 6 inches (152 mm) inboard or outboard of the inside surface of the lowest adjacent side handhold clear length. In addition, the outside edge of any step tread shall be no more than 2 inches (51 mm) inboard of any car structure below the lowest adjacent side handhold in the area from the inboard clearance point of the handhold to the outboard vertical leg of the step. If the clearance diagram of the railroad does not allow this 2 inch requirement to be achieved, up to 4 inches (102 mm) may be allowed provided the lowest tread is no more than

21 inches above the top of rail. See Figure 7.

5.4 Sill Step Handholds

5.4.1 General

Except as provided in Section 6, sill step handholds shall be applied over each sill step.

5.4.2 Purpose/Function

Sill step handholds are used to stabilize an employee while riding on the sill step.

5.4.3 Dimensions

Handholds shall be no less than 5/8 inch (16 mm) diameter. Minimum clear length of handholds shall be 16 inches (406 mm). Minimum clearance shall be 2 inches (51 mm), preferably 2.5 inches (64 mm).

5.4.4 Location (Figures 9-13)

a) There shall be a minimum of two handholds over each sill step. If it is not possible to place two handholds over a sill step, there shall be one handhold over that sill step and the railroad shall prohibit employees from riding on that sill step.

   Note: When only one sill step handhold is used, APTA recommends that a "DO NOT RIDE" sign be affixed to the car above the sill step.

b) When at least two horizontal handholds are used, one horizontal handhold shall be at most 54 inches (1372 mm) ATR. The second horizontal handhold shall be 54 to 58 inches (1372 to 1473 mm) above the step. See Figure 9.

c) When one horizontal handhold is used, it shall be 54 to 56 inches (1372 to 1423 mm) ATR. See Figure 10.

d) Twelve inches (305 mm) of the clear length of each horizontal handhold shall be directly over the sill step. See Figure 9.

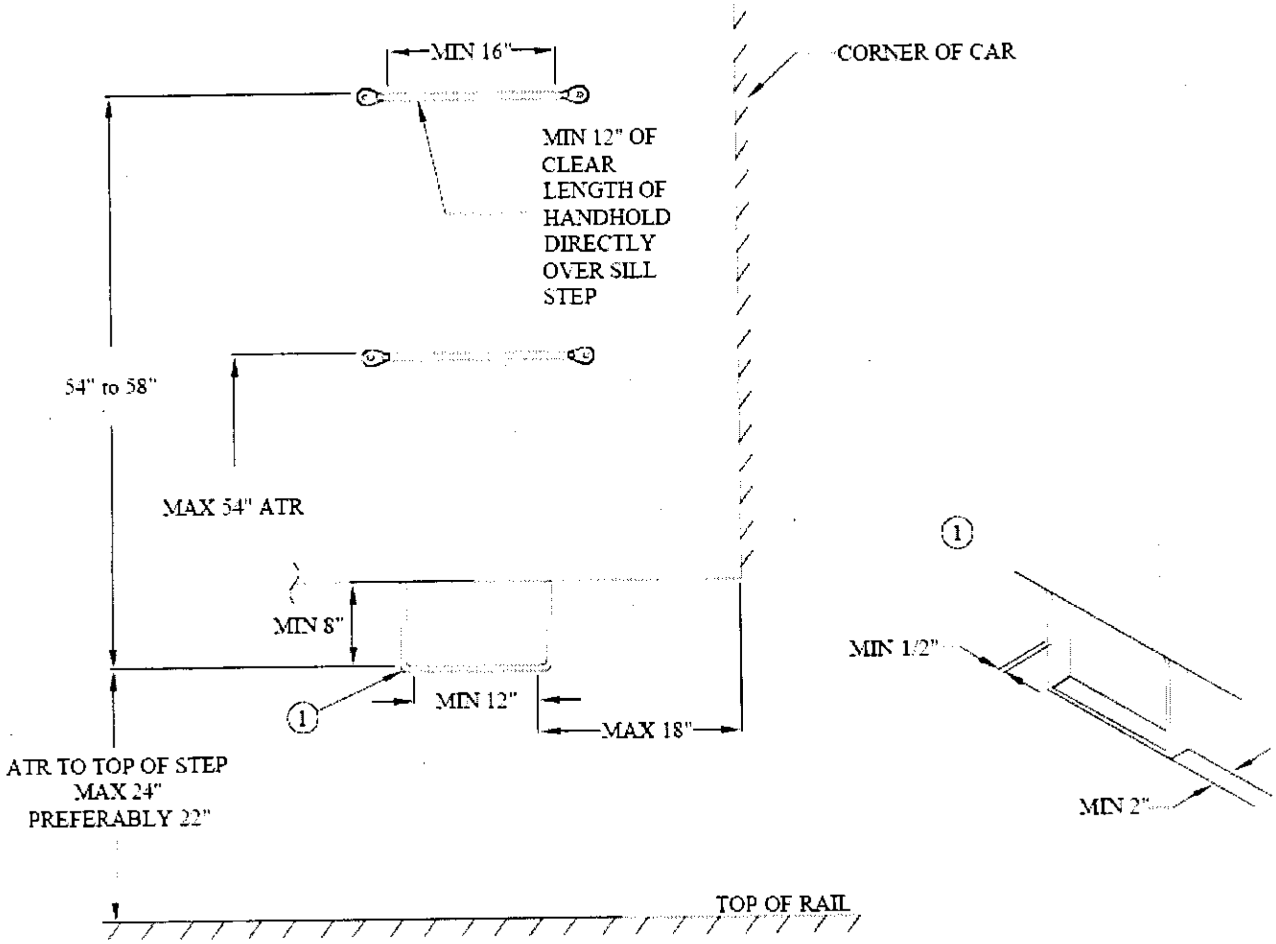

Figure 9 – Sill Step with Two Horizontal Handholds

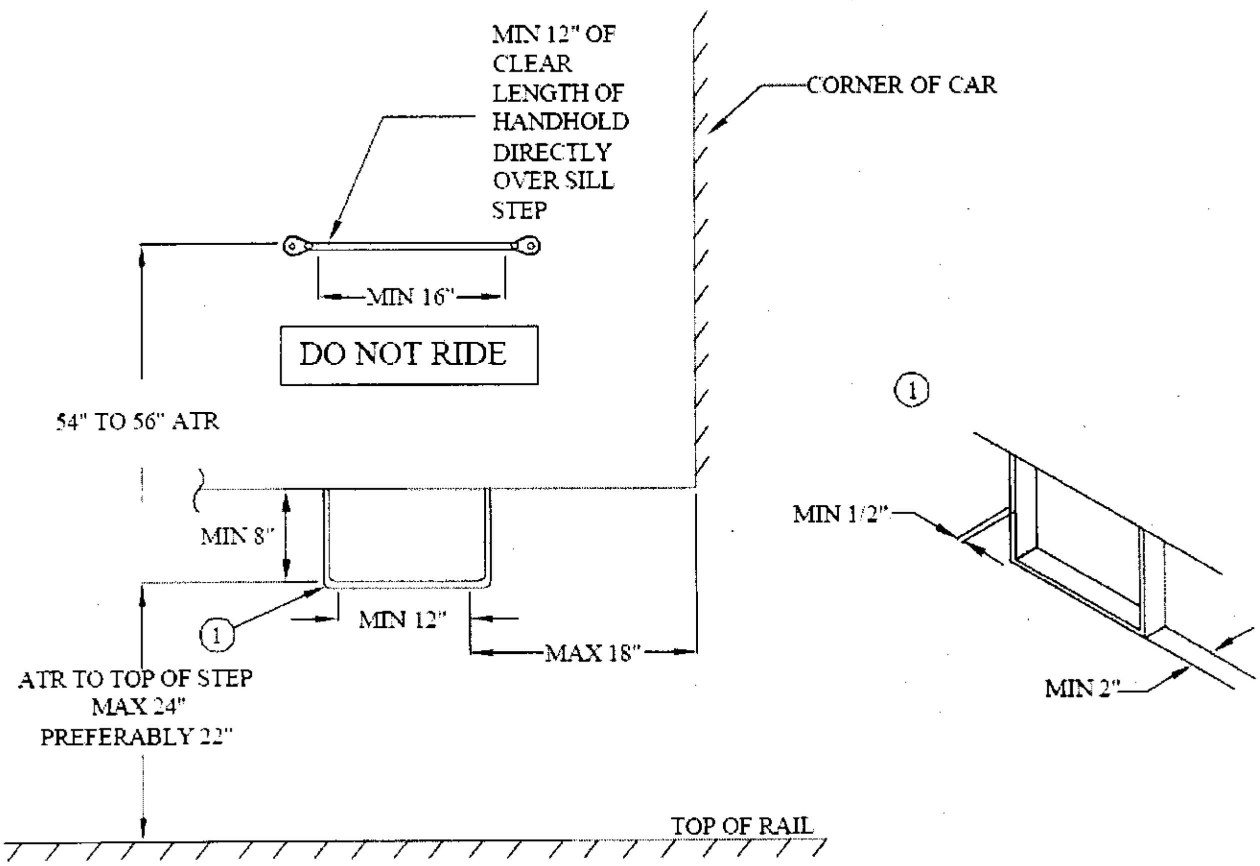

Figure 10 – Sill Step with One Horizontal Handhold

e) When at least two vertical handholds are used, the lowest clearance point of each vertical handhold shall be at most 54 inches (1372 mm) ATR. The highest clearance point of each vertical handhold shall be at least 58 inches (1473 mm) above the step. Each set of vertical handholds shall be spaced not less than 16 inches (406 mm) nor more than 22 inches (559 mm) apart. See Figure 11.

f) When one vertical handhold is used, its lowest clearance point shall be at most 54 inches (1372 mm) ATR. Its highest clearance point shall be at least 70 inches (1778 mm) ATR. See Figure 12. The handhold shall be located above the clear length of the step.

g) To align two vertical handholds with the sill steps, the handholds shall be located in the longitudinal direction such that the inside face of the outboard handhold is no more than 2 inches (51 mm) outboard of the inside face of the outboard vertical leg of the step and is no less than 10 inches (254 mm) outboard from the inside face of the inboard vertical leg. See Figure 11.

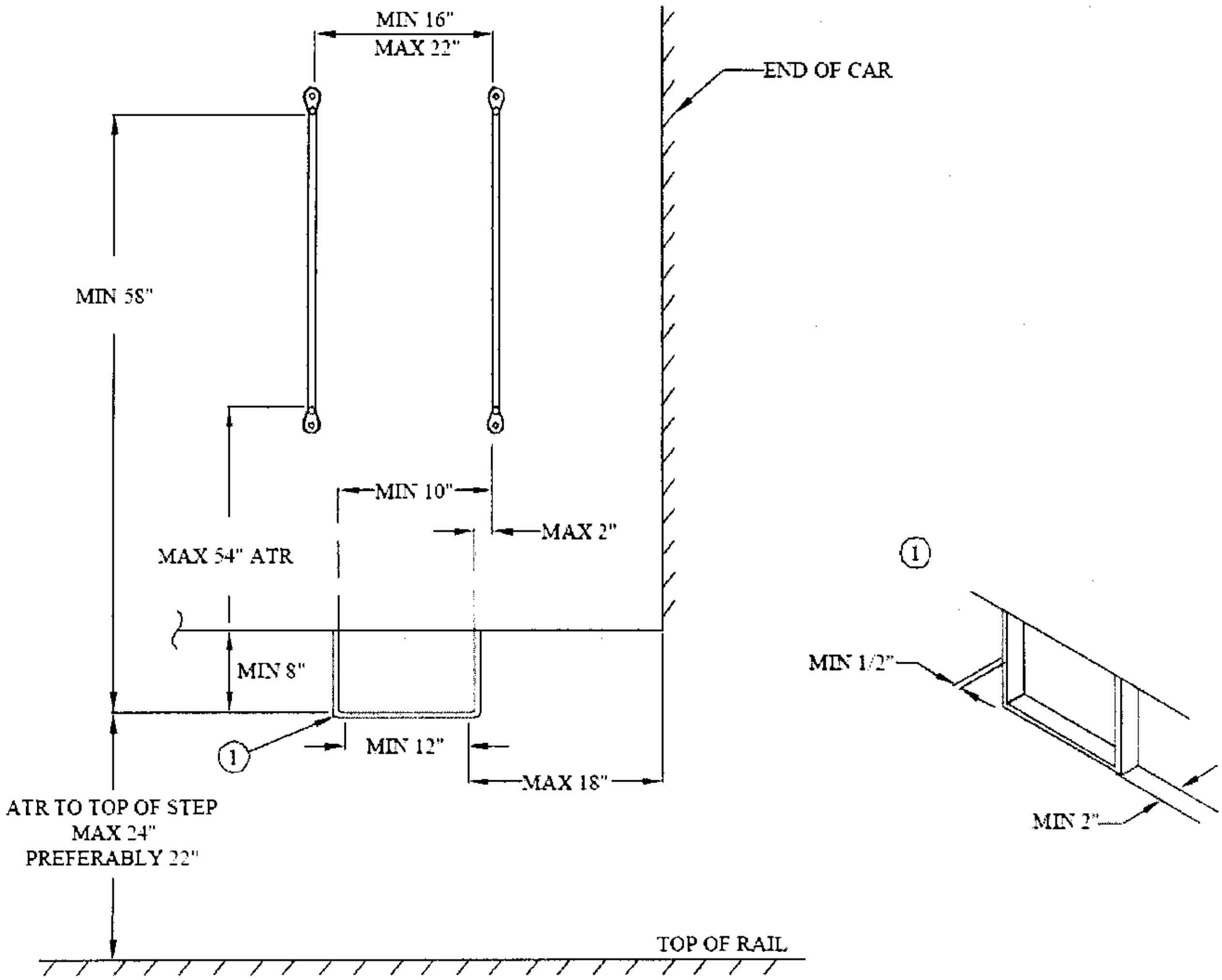

Figure 11 – Sill Step with Two Vertical Handholds

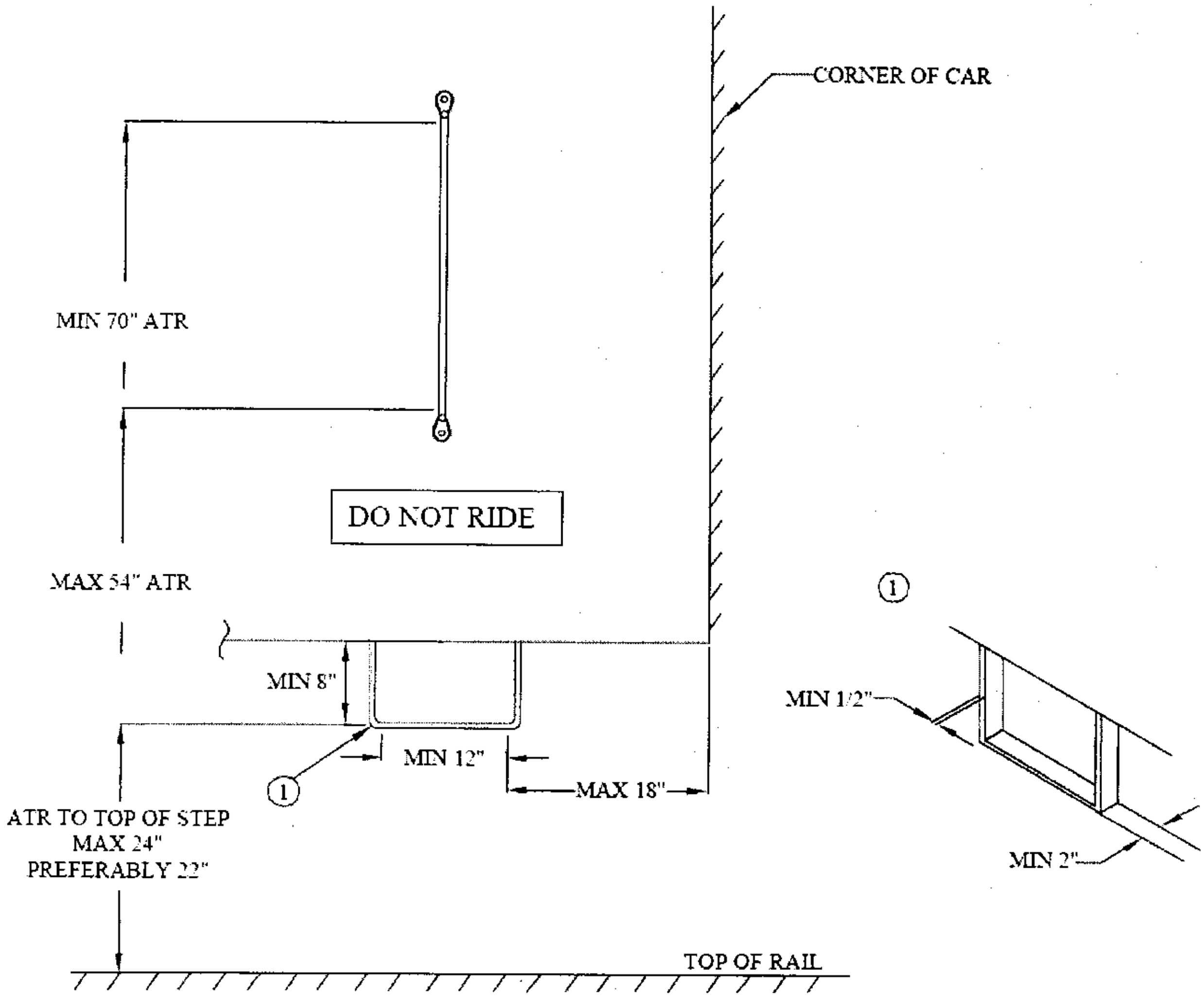

Figure 12 – Sill Step with One Vertical Handhold

h) When a combination of horizontal and vertical handholds is used, the horizontal handhold shall be 54 to 58 inches (1372 to 1473 mm) above the step. The lowest clearance point of the vertical handhold shall be at most 54 inches (1372 mm) ATR. The highest clearance point of the vertical handhold shall be at least 70 inches (1778 mm) ATR. See Figure 13. One continuous handhold may be used as long as it meets the dimensional requirements of this paragraph.

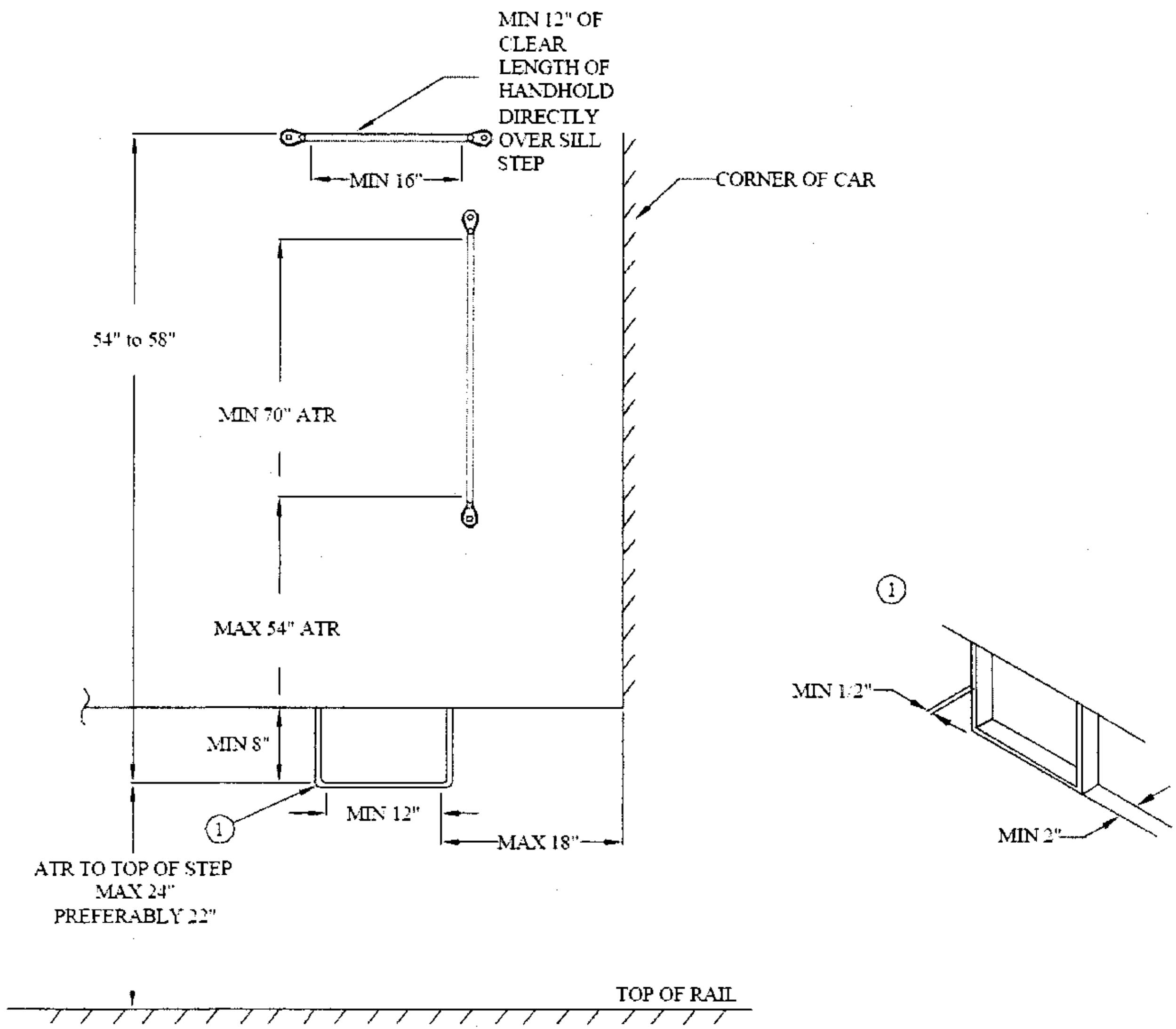

Figure 13 – Sill Step with One Horizontal and One Vertical Handhold

5.5 Side Door Handholds

5.5.1 General

Except as provided in Section 6, a side door handhold shall be applied over each side door step.

5.5.2 Purpose/Function

Side door handholds are used to assist an employee while entering or leaving a car.

5.5.3 Dimensions

Handholds shall be no less than 5/8 inch (16 mm) diameter. Minimum clear length of vertical handholds shall be 24 inches (610 mm). Minimum clearance shall be 2 inches (51 mm), preferably 2.5 inches (64 mm).

5.5.4 Location (Figures 14 and 15)

a) There shall be one vertical side door handhold over each side door step.

b) The lowest clearance point of the side door handhold shall be at most 54 inches (1372 mm) ATR.

c) If the side door handhold is located outside of the side door opening, the side door handhold shall be located no more than 6 inches (152 mm) from the vertical inside face of the door opening.

d) On cab cars with non-passenger side entrances, two vertical side door handholds shall be installed, one on each side of the door, to continue to a point at least 58 inches (1473 mm) above the cab floor at the door entrance. If the length of the handhold exceeds 60 inches (1524 mm), it shall be securely fastened with two fasteners at each end.

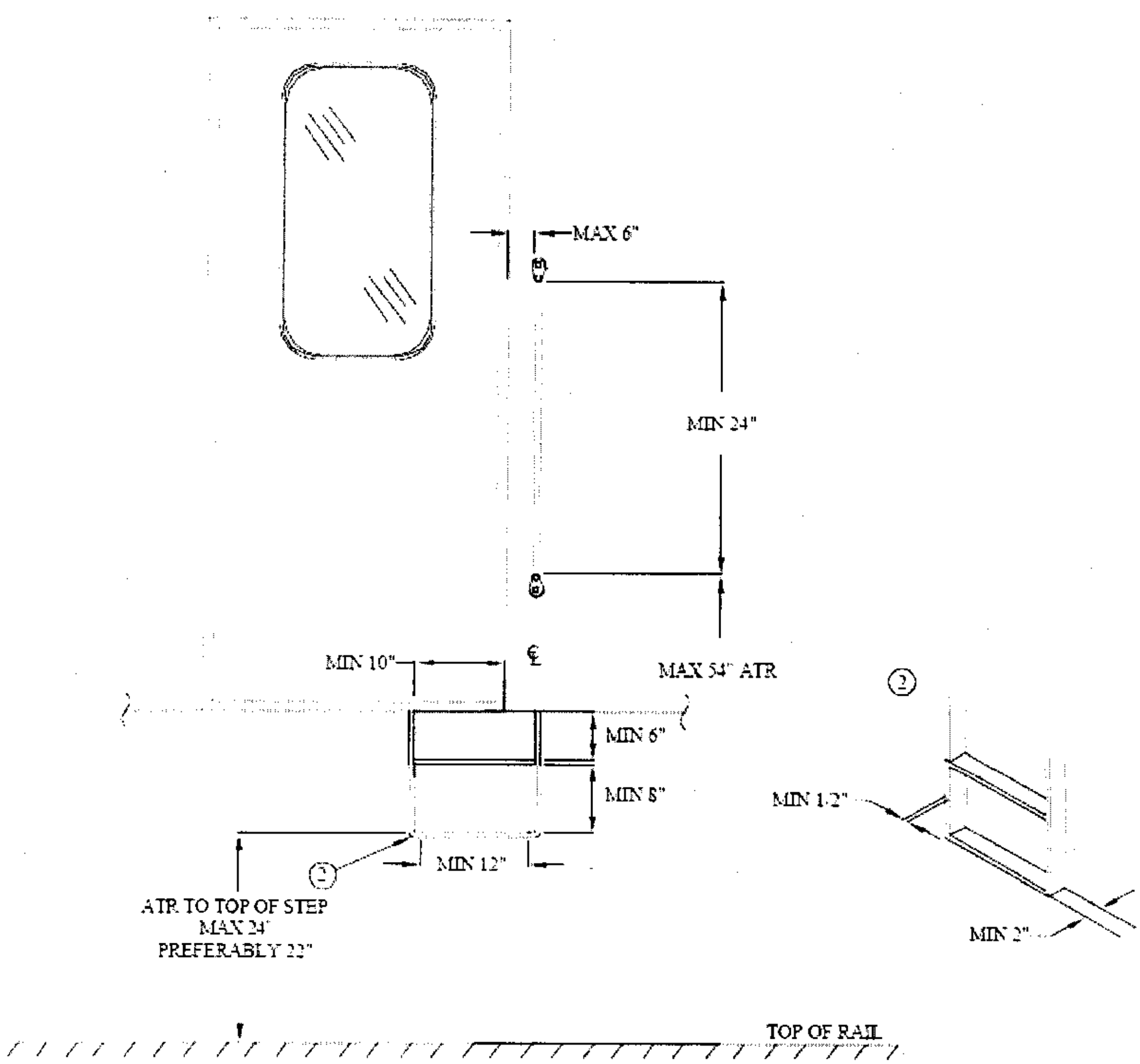

Figure 14 – Side Door Step with Vertical Handhold

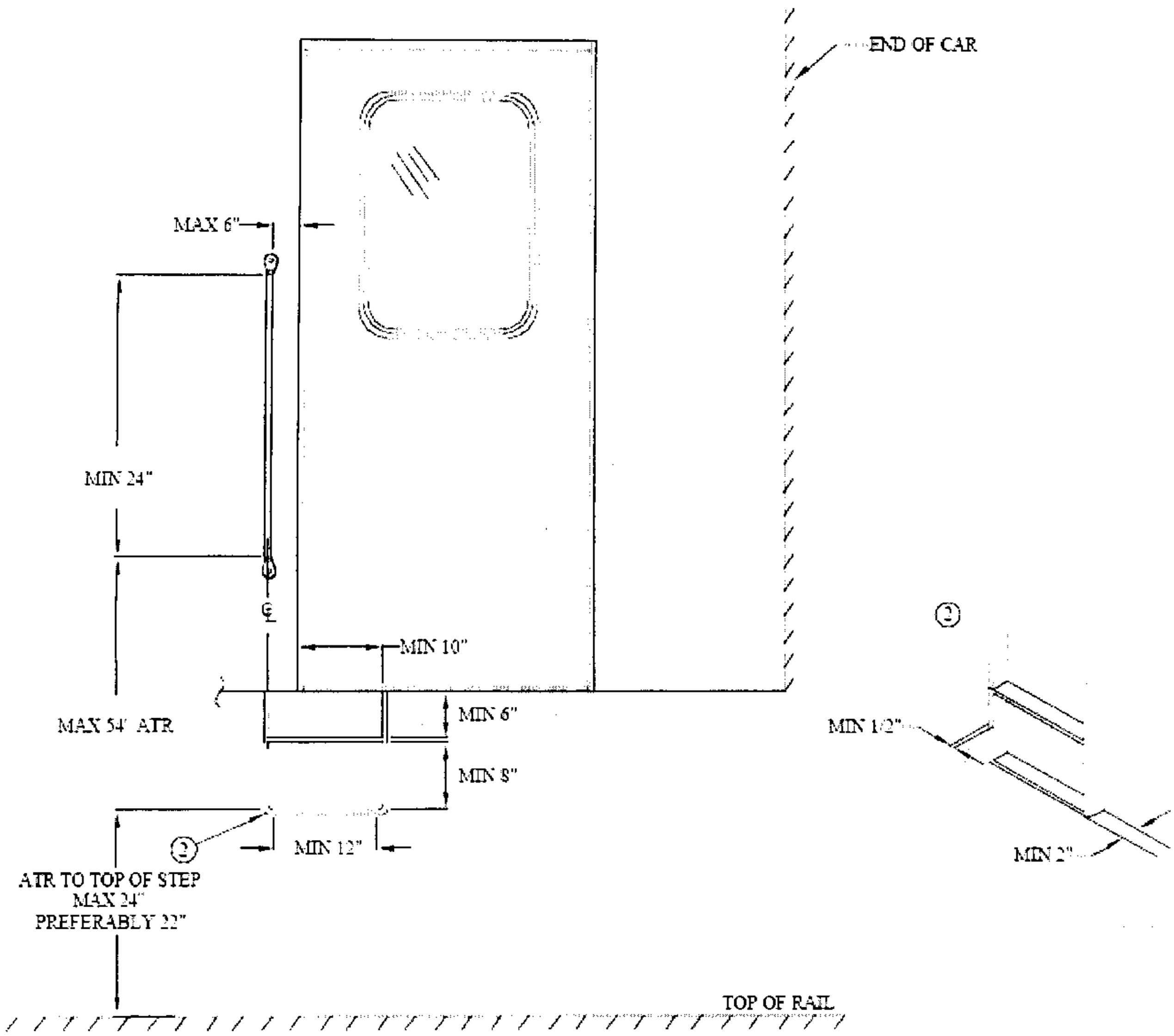

Figure 15 – Side Door Step with Vertical Handhold at End of Car

5.6 Crew Handholds at Passenger Steps Used in Lieu of Sill Steps

5.6.1 General

Except as provided in Section 6, on cars with passenger entrances with the lowest step at a height of 24 inches ATR or less to be used in lieu of sill steps, crew handholds shall be applied.

5.6.2 Purpose/Function

Crew handholds are used to stabilize an employee while riding passenger steps in lieu of sill steps.

5.6.3 Dimensions

Handholds shall be no less than 5/8 inch (16 mm) diameter. Minimum clear length of vertical handholds shall be 33 inches (838 mm). Minimum clearance shall be 2 inches (51 mm), preferably

2.5 inches (64 mm).

5.6.4 Location (Figure 16)

a) There shall be two vertical crew handholds, one on each side of the door opening.

b) The lowest clearance point of each crew handhold shall be at most 54 inches (1372 mm) ATR.

c) If the crew handhold is located outside of the door opening, the crew handhold shall be located no more than 6 inches from the vertical inside face of the door opening.

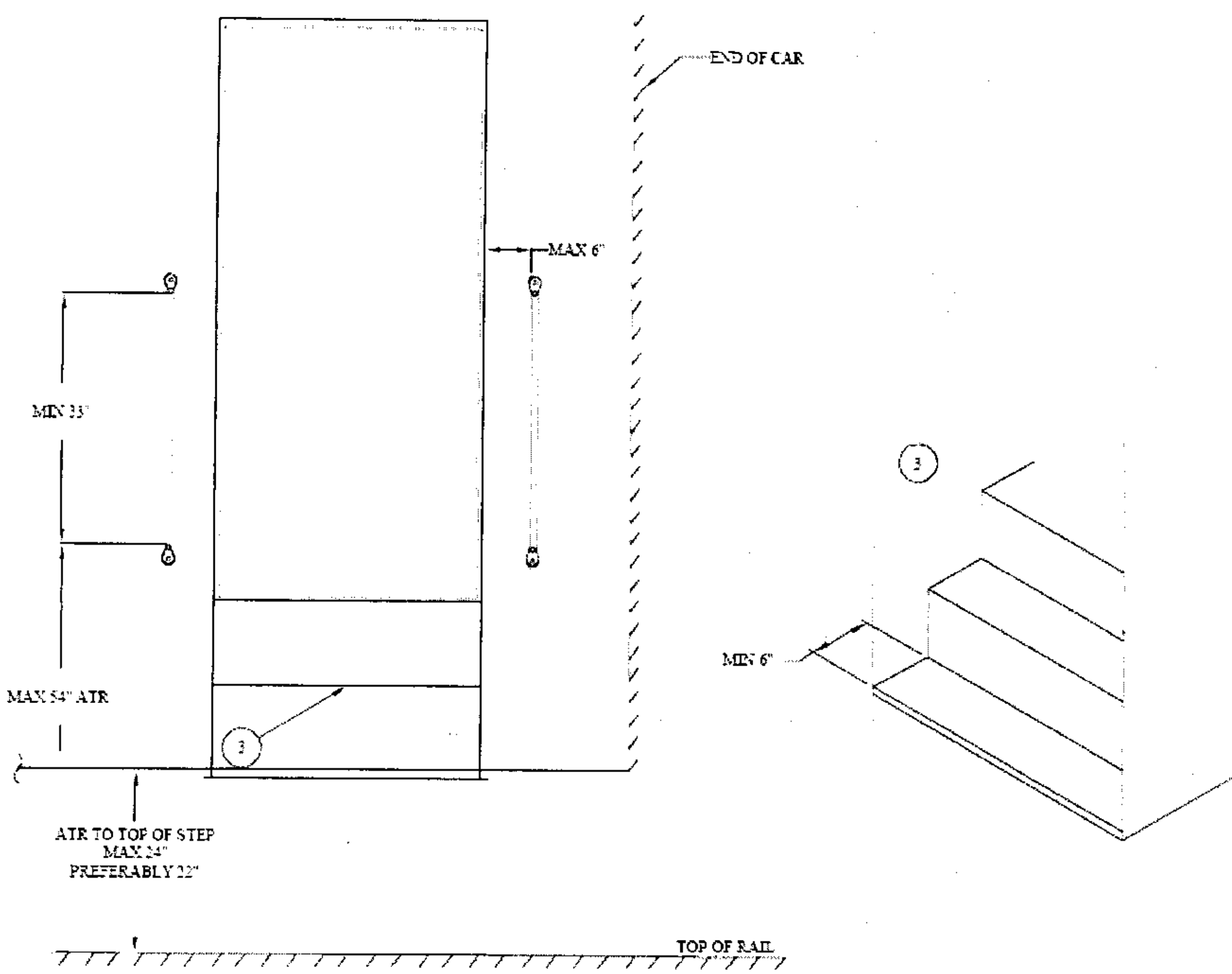

Figure 16 – Crew Handholds at Passenger Steps

5.7 End Handholds

5.7.1 General

Except as provided in Section 6, two end handholds shall be on each end of the car.

5.7.2 Purpose/Function

End handholds are used to stabilize an employee when performing such tasks as making or breaking end connections, opening and closing angle cocks and performing inspections.

5.7.3 Dimensions

Handholds shall be no less than 5/8 inch (16 mm) diameter. Minimum clear length of end handholds shall be 16 inches (406 mm). Minimum clearance shall be 2 inches (51 mm), preferably 2.5 inches (64 mm), with end connections applied and end receptacle covers in resting position.

5.7.4 Location (Figure 17)

End handholds shall be oriented horizontally, one near each side on each end projecting from the face of the end sill or sheathing. The clearance point of the outboard end of the end handhold shall be not more than 16 inches (406 mm) from side of car.

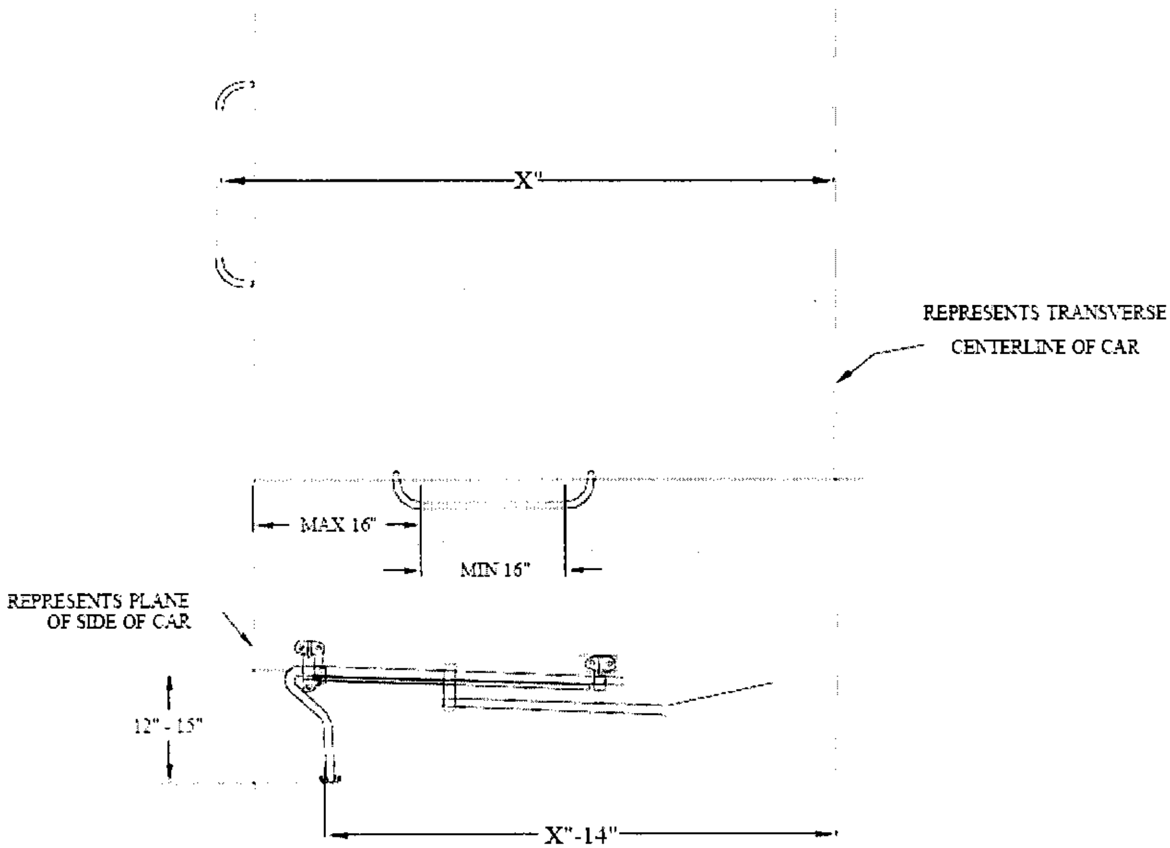

Figure 17 – End Handhold and Uncoupling Lever

5.8 Collision Post Handholds

5.8.1 General

Two collision post handholds shall be at each end passageway.

5.8.2 Purpose/Function

Collision post handholds provide a means to stabilize an employee standing at the end of the car guiding reverse moves. Collision post handholds also provide a means to stabilize an employee when walking between cars.

5.8.3 Dimensions

Handholds shall be no less than 5/8 inch (16 mm) diameter. Minimum clearance shall be 2 inches (51 mm), preferably 2.5 inches (64 mm).

5.8.4 Location (Figure 18)

Collision post handholds shall be oriented vertically. The lowest clearance point shall be at most 44 inches (1118 mm) above the floor of the walkway, and the highest clearance point shall be at least 60 inches (1524 mm) above the floor of the walkway.

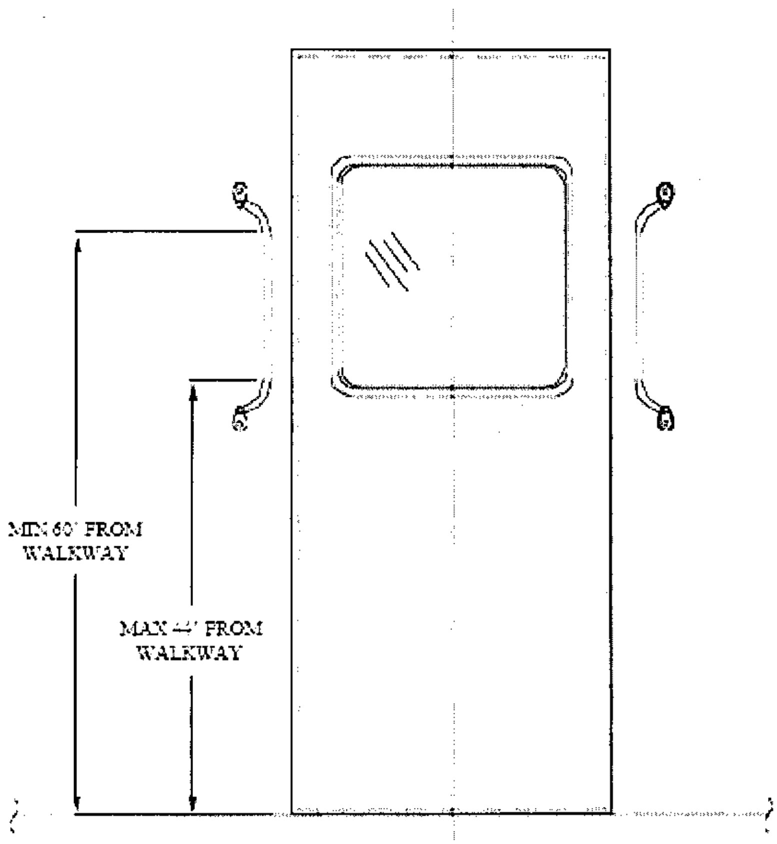

Figure 18 – Collision Post Handholds

5.9 Handrail on Open Platform Cars

5.9.1 General

Open platform cars shall have the platform area enclosed with either a handrail or shortened walls.

5.9.2 Purpose/Function

A handrail or a shortened wall is used on open platform cars to enclose the platform area and stabilize an employee standing on the open platform.

5.9.3 Dimensions

Handrails shall be no less than 1 inch (25.5 mm) diameter tubing with a minimum wall thickness of 1/16 inch (1.6 mm).

5.9.4 Location (Figure 19)

a) Open platform cars shall have the platform area enclosed with either a handrail or shortened walls. The handrail may be continuous or may be intermittent to extend between other members of the car such as collision posts and corner posts.

b) If an intermittent handrail is used, the end of the handrail shall be capped with a rounded end to reduce risk of injury.

c) The distance from the end of the handrail to a vertical car member shall not exceed 4 inches (102 mm).

d) The handrail shall be at least 42 inches (1071 mm) from the top of the platform floor to the top of the handrail, including entry doors.

e) The handrail arrangement shall be designed such that a 5 inch (127.5 mm) diameter ball cannot pass through any space between handrail members or between the handrail and the carbody.

f) Handrail members shall not be unsupported for spans over 48 inches (1224 mm).

g) The railing and stile assembly may be welded but the ends of the final assembly must be securely fastened to the car structure.

h) If a shortened wall is used, it shall meet the location requirement for handrails as detailed in items a) through g) above.

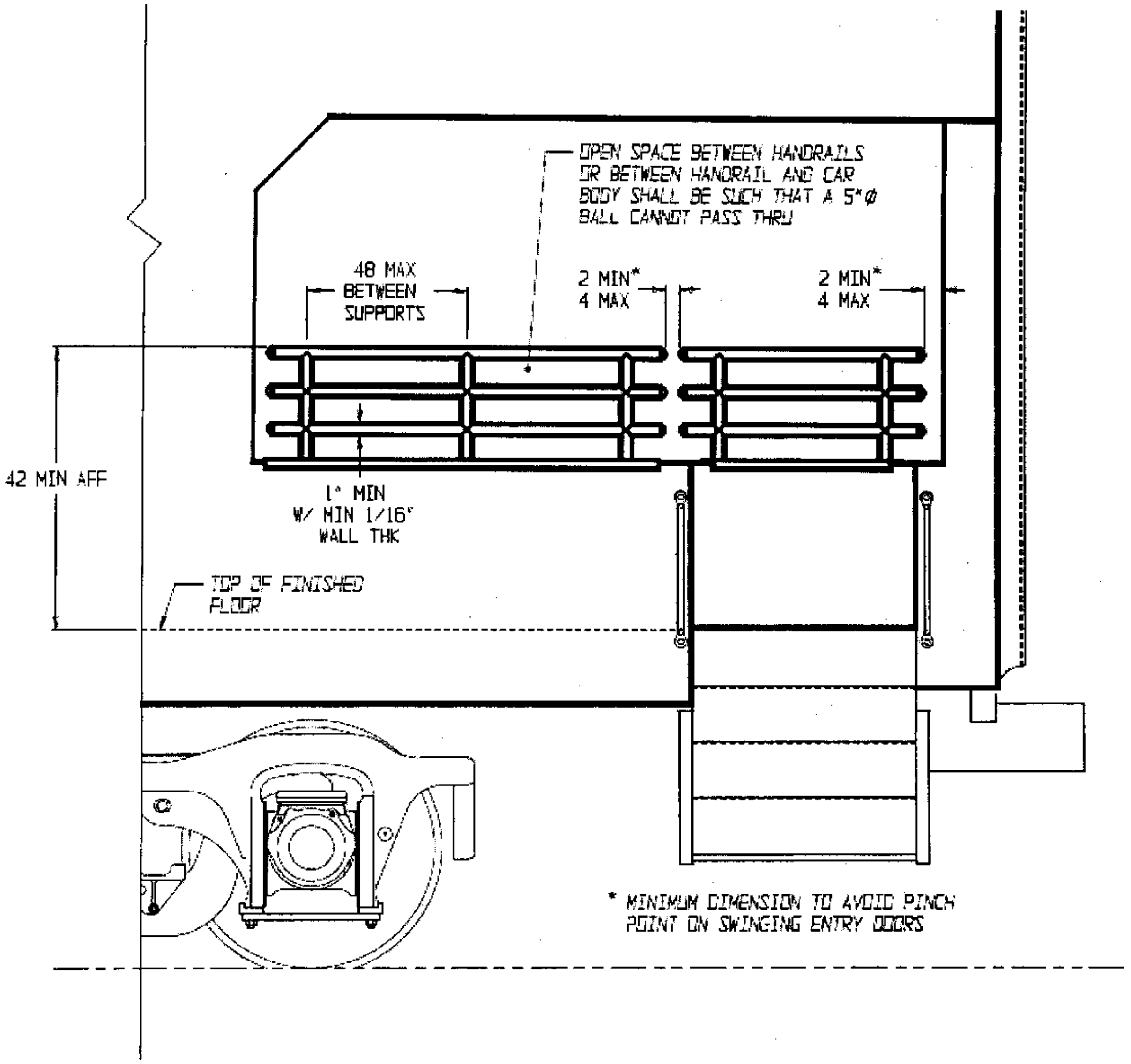

Figure 19 – Handrail on Open Platform Car

5.10 Uncoupling Devices

5.10.1 General

Except as provided in Section 6, each car shall have either a mechanical uncoupling device at each end of the car or an uncoupling mechanism operated by controls located in a secure location in the car.

5.10.2 Purpose/Function

The uncoupling device is a mechanism used to uncouple cars without requiring an employee to go between cars.

5.10.3 Dimensions

If the uncoupling device is mechanically operated from the side of the car, the following shall apply:

a) Under all operating conditions, the outside surface of the uncoupling device handles shall be no more than 14 inches (356 mm) closer to the car center than the inside surface of the adjacent side handhold. See Figure 17.

b) Uncoupling attachments shall be applied so they can be operated by a person standing on the ground.

c) The bottom end of the handle shall be no less than 12 inches (305 mm) and no more than 15 inches (381 mm) below the centerline of the outermost pivot point of the uncoupling lever to which the handle is attached.

d) The end of handle shall be constructed to provide a minimum 2 inches (51 mm) clearance around the handle.

5.10.4 Location (Figure 17)

When used, the uncoupling levers shall be so applied that the coupler can be operated from the left side of the car as seen when facing the end of the car from the ground.

5.10.5 Manner of Application

The uncoupling lever device shall be securely fastened to the carbody structure or supporting bracket.

5.11 Elective Safety Appliances

Safety appliances applied to the exterior of cars in addition to those required by this standard are defined as "Elective Safety Appliances" and shall comply with the requirements of this standard that are applicable to similar safety appliances, except for their quantity and location.

5.11.1 General

When marker sockets or brackets are located so that they cannot be conveniently reached from platforms, suitable steps and handholds shall be provided for employees to reach such sockets or brackets. These steps and handholds shall follow the requirements for side door steps and side door handholds respectively. Alternately, the requirements for ladders may be used.

5.11.2 Ladders

5.11.2.1 Purpose/Function

Ladders are not required and are elective safety appliances. Ladders enable an employee to access equipment or to perform a function that cannot be done from the ground.

5.11.2.2 Dimensions

a) The minimum useable length of tread shall be not less than 16 inches (406 mm) on side ladders and not less than 14 inches (356 mm) on end ladders.

b) Treads of rectangular cross-section shall be no less than 1/2 inch (13 mm) thick and no less than 2 inches (51 mm) wide. The minimum diameter of treads of circular cross-section shall be 5/8 inch (16 mm).

c) Minimum clearance of treads shall be 2 inches (51 mm), preferably 2.5 inches (64 mm).

d) All ladder treads shall have foot guards. Ladder side rails may serve as foot guards (Figure 20).

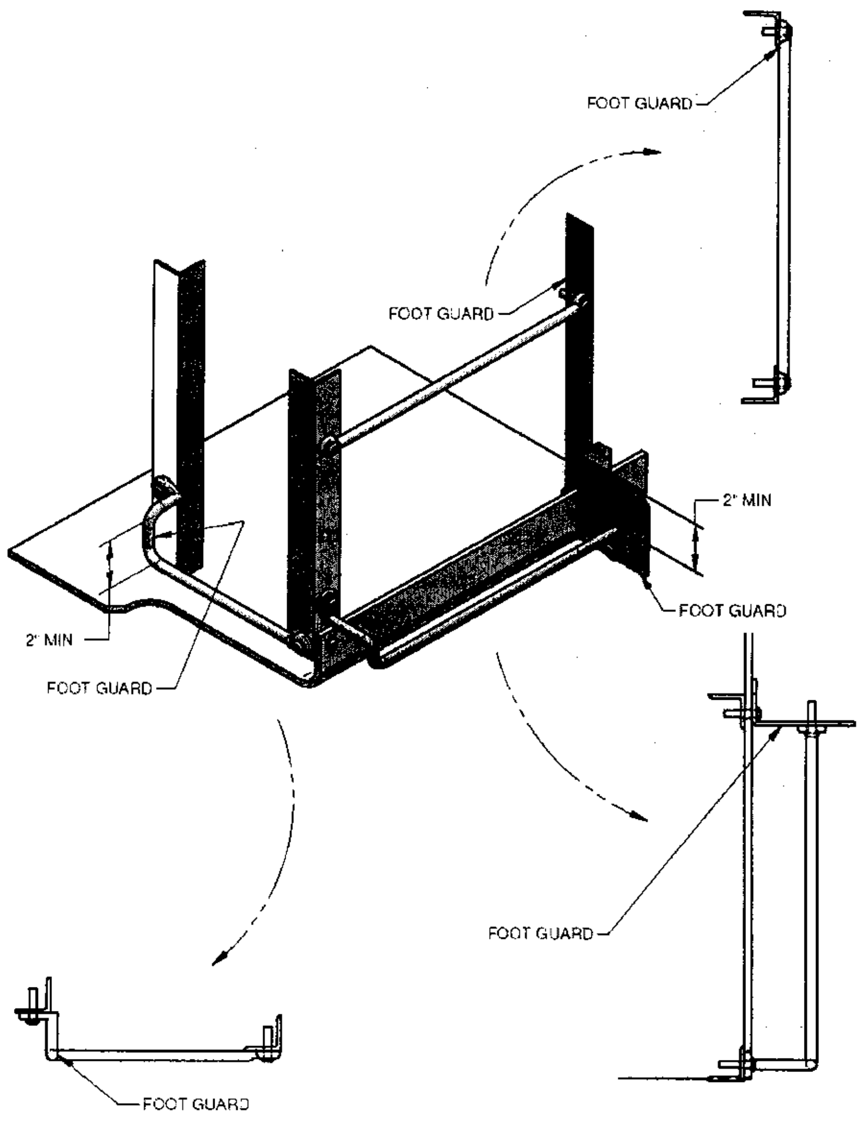

Figure 20 – Foot Guards on Ladder Treads

5.11.2.3 Location

a) If the ladder is used for access to the roof, the top ladder tread shall be no less than 12 inches (305 mm), nor more than 18 inches (457 mm), below the mounting surface of the outboard end of the adjacent roof handhold.

b) The maximum spacing between ladder treads shall be 19 inches (483 mm). Spacing of ladder treads shall be uniform within a limit of 2 inches (51 mm) from top ladder tread to bottom tread of ladder.

5.11.3 Roof Handholds

5.11.3.1 Purpose/Function

Roof handholds are not required and are elective safety appliances. Roof handholds are used on the roof of the car to stabilize an employee when performing such tasks as inspecting equipment located on the roof.

5.11.3.2 Dimensions

Handholds shall be no less than 5/8 inch (16 mm) diameter. Minimum clear length shall be 16 inches (406 mm). Minimum clearance shall be 2 inches (51 mm), preferably 2.5 inches (64 mm).

5.11.3.3 Location

If roof handholds are located above a ladder, in the transverse direction, the clearance points of the inboard end of roof handholds (bulkhead top handholds) shall be no more than 8 inches (203 mm) inboard from and no further outboard than the clearance point of the inboard end of the top ladder tread.

6. Semi-permanently Coupled Cars

Semi-permanently coupled cars need not be equipped with uncoupling levers, sill steps or end or side handholds at the articulated or drawbar connections between adjacent carbodies. However, when elective safety appliances are applied at such locations, they shall comply with the requirements of paragraph 5.10 of this standard.

Semi-permanently coupled cars shall be equipped with sufficient handbrakes/parking brakes to meet the grade holding capacity defined in APTA SS-M-006-98, Rev. 1.

7. Safety Appliance Design Verification Inspection

The railroad and the carbuilder may use the checklist in Annex A to verify that all the requirements of this standard have been addressed.

The carbuilder or railroad shall request a safety appliance sample car inspection from the FRA in the United States or Transport Canada in Canada on each new design of car. If any design changes take place to safety appliances during production, the carbuilder or railroad shall request an additional safety appliance sample car inspection.

Previous sample car inspections can be applied to new orders of the same design if there are no changes to the safety appliances. However, FRA and Transport Canada will require submittal of the safety appliance arrangement drawings for that order with reference to the previous sample car inspection.

This inspection can be combined with the standard sample car inspection. Both FRA and Transport Canada require inspection of items in addition to safety appliances during the sample car inspection.

Contact FRA and/or Transport Canada for details on these requirements.

It is recommended that a safety appliance design review with the FRA or Transport Canada be conducted as early as possible in the design process. The carbuilder or railroad shall submit a written request to FRA and/or Transport Canada at least 30 days prior to a sample car inspection. The letter shall include the drawings of all safety appliances and may include the completed checklist in Annex A. The letter shall be sent to:

Federal Railroad Administration:

Director, Office of Safety Assurance and Compliance
Federal Railroad Administration
U.S. Department of Transportation
400 7th Street, SW
Mail Stop 25
Washington, DC 20590

Transport Canada:

Transport Canada
Rail Safety
Enterprise Building
427 Laurier Avenue West
14th floor Suite 1410
Ottawa, Ontario
Canada, K1A 0N5

8. Inspection, Maintenance, Repair and Replacement

8.1 Inspection

Safety appliances shall be inspected in accordance with 49 CFR 238.303, APTA SS-I&M-007-98, Rev. 1, and Transport Canada's Railway Passenger Car Inspection and Safety Rules.

Safety appliances shall be part of the periodic inspection of the car in accordance with 49 CFR 238.307, APTA SS-I&M-007-98, Rev. 1, and Transport Canada's Railway Passenger Car Inspection and Safety Rules.

8.2 Maintenance

Any safety appliance defects uncovered in the inspections required in Section 8.1 shall be repaired in accordance with 49 CFR 238.303; 49 CFR 238.307; APTA SS-I&M-007-98, Rev. 1; and Transport Canada's Railway Passenger Car Inspection and Safety Rules.

8.3 Repair and Replacement

When damaged safety appliances and/or their brackets or supporting structure are repaired or replaced, they shall be restored to their original design. See also APTA SS-C&S-020-03, Standard for Passenger Rail Vehicle Structural Repair.

Fastener locking devices shall not be reused.

Bibliography

AAR Manual of Standards and Recommended Practices, Section B, S-132, Type No. 6 Operating Mechanism

AAR Manual of Standards and Recommended Practices, Section C, S-224, Handhold and Ladder Tread Material and Design Specifications

AAR Manual of Standards and Recommended Practices, Section C, S-2042, Sill Step Performance Specification

AAR Manual of Standards and Recommended Practices, Section E, S-475, Geared Hand Brakes

FRA Motive Power and Equipment Compliance Manual, Chapter 2, Inspection and Compliance Program

SAE J429, 1999, Mechanical and Material Requirements for Externally Threaded Fasteners

Annex A (informative) Sample Car Inspection Checklist

Safety Appliance Design Review Checklist
Edited: 2-9-07

Reviewer: | Organization: | Date: | Region:

Builder: | Car Initials & Series: | Car Type: | Cars to be Built: | Builder Job #

Item	**#**		**Number - Dimensions - Location - Manner of Application**	**APTA SS-M-016-06 Reference**	**Notes**
Handbrake / Parking Brake	1.	☐	Each car has a handbrake or parking brake.	5.1.1	
	2.	☐	If parking brake is used, can be set from each car and can be released manually.		
	3.	☐	Located so as to not restrict passenger flow through any passageway, whether applied or released and in its stored position.	5.1.3.1	
	4.	☐	Located so it can be safely operated while the car is in motion.		
	5.	☐	A handhold is provided to stabilize an employee when using the handbrake.		
	6.	☐	Center point of the wheel or the pivot point of the lever is located 31 to 40 inches above floor.		
	7.	☐	Handbrake Housing and mounting brackets are securely fastened.	5.1.4	
			Lever Type Handbrake Only:	5.1.3.2	
	8.	☐	Handle retention mechanism does not interfere with the normal grip position of the lever.		
	9.	☐	In stored position, handbrake lever and release lever have a minimum 2 inch hand clearance.		
	10.	☐	In operating position, lever has a minimum 24 inch body clearance on one side of the lever and a minimum 4 inch hand clearance on the opposite side.		
	11.	☐	Clearance between the grip portion of the release lever, if used, and any part of the car is no less than 2.5 inches.		

Handbrake / Parking Brake continued		*Wheel Type Handbrake Only:*		5.1.3.3	
	12.	☐	The wheel type handbrake has a minimum 4 inch hand clearance.		
	13.	☐	The wheel diameter is at least 22 inches.		
		Parking Brake Only:		5.1.3.4	
	14.	☐	Manual release lever has a minimum 2 inch hand clearance.		
Sill Steps	15.	☐	Securely fastened to the carbody structure.	4.4	
	16.	☐	Welds done in accordance with the standard and with proper welding procedures.		
	17.	☐	Minimum useable length 12 inches.	5.2.3	
	18.	☐	Minimum 1/2 inch thick and 2 inches wide. Alternate material sections may be used if they maintain the equivalent strength and rigidity of a 1/2 inch (13 mm) thick by 2 inch (51 mm) width step.		
	19.	☐	Minimum clear depth, 8 inches.		
	20.	☐	Minimum clear width 6 inches with trucks rotated to simulate the maximum curvature specified for the uncoupled car.		
	21.	☐	10 inch x 8 inch x 6 inch test box passes through opening above each sill step so box is flush with outer edge of step.		
	22.	☐	One sill step is located at each corner of the car. A passenger step may be used in lieu of a sill step if it meets the clear depth, clear width, useable length and location requirements for a sill step.	5.2.4	
	23.	☐	Outboard end of the useable length, not more than 18 inches in the longitudinal direction from the corner of the car. For cars without well-defined corners, the intent is for the sill step to be positioned for the employee to have an unobstructed view of the track ahead. The sill step shall be placed so the employee has a clear view in both longitudinal directions and shall be placed outside of the gauge of the track.		
	24.	☐	Steps exceeding 18 inches in depth are transversely braced or equivalent.		
	25.	☐	Sill step tread, maximum 24 inches ATR.		
	26.	☐	Outside edge of any sill step tread, not more than 4 inches inboard or outboard of the inside surface of the lowest adjacent side handhold.		

Sill Steps Continued	27.	☐	The outside edge of any sill step tread is no more than 2 inches (4 inches if clearance diagram does not allow 2 and if the step tread is maximum 21 inches ATR) inboard of any car structure below the lowest adjacent side handhold in the area from the inboard clearance point of the handhold to the outboard vertical leg of the sill step.	5.2.4	
Side Door Steps	28.	☐	At least one side door step per car side on cars that do not have a minimum of one passenger entrance per car side of a height of 24 inches ATR or less.	5.3.1	
	29.	☐	Securely fastened to the carbody structure.	4.4	
	30.	☐	Welds done in accordance with the standard and with proper welding procedures.		
	31.	☐	Minimum useable length, 12 inches.	5.3.3	
	32.	☐	Minimum 1/2 inch thick and 2 inches wide. If alternate material sections are used, they maintain the equivalent strength and rigidity of a 1/2 inch thick and 2 inches wide step. Tread width is 2 inch minimum.		
	33.	☐	Steps exceeding 18 inches in depth have an additional tread and are transversely braced or equivalent.		
	34.	☐	Minimum clear depth of lowest side door step, 8 inches.		
	35.	☐	Minimum clear depth of all side door steps except lowest, 6 inches.		
	36.	☐	Minimum clear width 6 inches with trucks rotated to simulate the maximum curvature specified for the uncoupled car.		
	37.	☐	10 inch x 8 inch x 6 inch test box passes through opening above the lowest side door step so box is flush with outer edge of step.		
	38.	☐	10 inch x 6 inch x 6 inch test box passes through opening above all side door steps except the lowest, so box is flush with outer edge of step.		
	39.	☐	For side door steps that extend beyond the side door opening in the longitudinal direction, inside face of the leg of side door step located under door opening is minimum 10 inches in the longitudinal direction from the vertical inside face of the door opening. Inside face of opposite leg of the side door step is located on the centerline of the side door handhold or extends beyond it.	5.3.4	
	40.	☐	Side door step tread maximum 24 inches ATR.		
	41.	☐	Outside edge of any side door step tread minimum 6 inches inboard or outboard of the inside surface of the lowest adjacent side handhold.		

Side Door Steps Continued	42.	☐	The outside edge of any sill step tread is no more than 2 inches (4 inches if clearance diagram does not allow 2 and if the step tread is maximum 21 inches ATR) inboard of any car structure below the lowest adjacent side handhold in the area from the inboard clearance point of the handhold to the outboard vertical leg of the side door step.	5.3.4	
Sill Step Handholds	43.	☐	Minimum of two handholds over each sill step. If it is not possible to place 2 handholds over a sill step, there shall be at least 1 handhold over that sill step and the railroad shall prohibit employees from riding on that sill step.	5.4.4	
	44.	☐	Minimum diameter, 5/8 inch.	5.4.3	
	45.	☐	Minimum clear length, 16 inches.		
	46.	☐	Minimum clearance, 2 inches.		
	47.	☐	Securely fastened to the carbody structure.	4.4	
	48.	☐	Welds done in accordance with the standard and with proper welding procedures.		
		Combination Sill Step Handholds Only:			
	49.	☐	When a combination of horizontal and vertical handholds is used, the horizontal handhold is 54 to 58 inches above the step. Lowest clearance point of the vertical handhold maximum 54 inches ATR. Highest clearance point of the vertical handhold minimum 70 inches ATR.	5.4.4	
		Horizontal Sill Step Handholds Only:			
	50.	☐	If 2 horizontal handholds are used, one handhold maximum 54 inches ATR. Second handhold is 54 to 58 inches above the step.	5.4.4	
	51.	☐	If 1 horizontal handhold is used, it is 54 to 56 inches ATR.		
	52.	☐	12 inches of the clear length of the handhold(s) is directly over the sill step.		
		Vertical Sill Step Handholds Only:			
	53.	☐	If 2 vertical handholds are used, the lowest clearance point of each is maximum 54 inches ATR. Highest clearance point of each is at least 58 inches above the step.	5.4.4	
	54.	☐	Each set of vertical handholds spaced 16 to 22 inches apart.		
	55.	☐	If 1 vertical handhold is used, the lowest clearance point is maximum 54 inches ATR. Highest clearance point is at least 70 inches ATR.		
	56.	☐	Inside of the outboard handhold maximum 2 inches outboard of the inside face of the outboard vertical leg of the step and minimum 10 inches outboard from the inside face of the inboard vertical leg.		

Side Door Handholds	57	☐	A vertical side door handhold is applied over each side door step	5.5.1, 5.5.4	
	58.	☐	Securely fastened to the carbody structure.	4.4	
	59.	☐	Welds done in accordance with the standard and with proper welding procedures.		
	60.	☐	Minimum diameter, 5/8 inch.	5.5.3	
	61.	☐	Minimum clear length, 24 inches.		
	62.	☐	Minimum clearance, 2 inches.		
	63.	☐	Lowest clearance point, maximum 54 inches ATR.	5.5.4	
	64.	☐	If the side door handhold is located outside of the side door opening, the side door handhold is located maximum 6 inches from the vertical inside face of the door opening.		
	65.	☐	On cab cars with non-passenger side entrances, vertical side door handholds shall be installed to continue to a point minimum 58 inches above the cab floor at the door entrance. If the length of the handhold exceeds 60 inches, it is securely fastened with two fasteners at each end.		
Crew Handholds at Passenger Steps	66.	☐	On cars with passenger entrances at a height of 24 inches ATR or less, crew handholds are applied above at least one passenger entrance per car side.	5.6.1	
	67.	☐	Securely fastened to the carbody structure.	4.4	
	68.	☐	Welds done in accordance with the standard and with proper welding procedures.		
	69.	☐	Minimum diameter, 5/8 inch.	5.6.3	
	70.	☐	Minimum clear length, 33 inches.		
	71.	☐	Minimum clearance, 2 inches.		
	72.	☐	There are two vertical crew handholds, one on each side of the door opening.	5.6.4	
	73.	☐	Lowest clearance point, maximum 54 inches ATR.		
	74.	☐	If the crew handhold is located outside of the side door opening, the crew handhold is located maximum 6 inches from the vertical inside face of the door opening.		
End Handholds	75.	☐	Two horizontal end handholds are located on each end of the car, one near each side on each end projecting from the face of the end sill or sheathing.	5.7.1, 5.7.4	
	76.	☐	Securely fastened to the carbody structure.	4.4	
	77.	☐	Welds done in accordance with the standard and with proper welding procedures.		
	78.	☐	Minimum diameter, 5/8 inch.		

End Handholds Continued	79.	☐	Minimum clearance, 2 inches.	5.73	
	80.	☐	Minimum clear length, 16 inches.	5.7.3	
	81.	☐	Clearance point of the outboard end of the end handhold is maximum 16 inches from side of car.	5.7.4	
Collision Post Handholds	82.	☐	Two vertical collision post handholds at each end passageway.	5.8.1, 5.8.4	
	83.	☐	Securely fastened to the carbody structure.	4.4	
	84.	☐	Welds done in accordance with the standard and with proper welding procedures.		
	85.	☐	Minimum diameter, 5/8 inch.	5.8.3	
	86.	☐	Minimum clearance, 2 inches.		
	87.	☐	Lowest clearance point, maximum 44 inches above the walkway.	5.8.4	
	88.	☐	Highest clearance point, minimum 60 inches above the walkway.		
Handrail on Open Platform Cars	89.	☐	Platform area enclosed with either a handrail or shortened walls.	5.9.1, 5.9.4	
	90.	☐	Railing and stile assembly may be welded but the ends of the final assembly must be securely fastened to the carbody structure.	4.4, 5.9.4	
	91.	☐	Welds done in accordance with the standard and with proper welding procedures.	4.4	
	92.	☐	Minimum handrail diameter, 1 inch.	5.9.3	
	93.	☐	Minimum wall thickness, 1/16 inch.		
	94.	☐	If intermittent handrail is used, end of the handrail is capped with a rounded end to reduce risk of injury.	5.9.4	
	95.	☐	Maximum distance from end of handrail to a vertical car member, 4 inches.		
	96.	☐	Minimum length from top of the platform floor to the top of the handrail, including entry doors, 42 inches.		
	97.	☐	Handrail designed such that a 5 inch diameter ball cannot pass through any space between handrail members or between the handrail and the carbody.		
	98.	☐	Handrail members shall not be unsupported for spans over 48 inches.		
	99.	☐	If shortened wall is used, it meets the location requirements for handrails as detailed above.		
Uncoupling Devices	100.	☐	Each car has either a mechanical uncoupling device at each end of the car, located so that it can be operated from the left side of the car as seen when facing the end of the car from the ground, or an uncoupling mechanism operated by controls located in a secure location in the car.	5.10.1, 5.10.4	

Uncoupling Devices Continued	101.	☐	Securely fastened to the carbody structure.	4.4	
	102.	☐	Welds done in accordance with the standard and with proper welding procedures.		
		Only If Mechanically Operated From Side Of Car:		5.10.3	
	103.	☐	Under all operating conditions, outside surface of uncoupling device handles maximum 14 inches closer to the car center than the inside surface of the adjacent side handhold.		
	104.	☐	Uncoupling attachments are applied so they can be operated by a person standing on the ground.		
	105.	☐	Bottom end of the handle is between 12 and 15 inches below the centerline of the outermost pivot point of the uncoupling lever to which the handle is attached.		
	106.	☐	Minimum 2 inches clearance around the handle at its end.		
	107.	☐	Securely fastened to the carbody structure or supporting bracket.	5.10.5	
Elective Safety Appliance - Ladder	108.	☐	Securely fastened to the carbody structure.	4.4	
	109.	☐	Welds done in accordance with the standard and with proper welding procedures.		
	110.	☐	Minimum useable length, 16 inches on side ladders and 14 inches on end ladders.	5.11.2.2	
	111.	☐	If rectangular cross section, treads are minimum 1/2 inch thick and minimum 2 inches wide.		
	112.	☐	If circular cross-section, minimum tread diameter, 5/8 inch.		
	113.	☐	Minimum tread clearance, 2 inches.		
	114.	☐	All ladder treads have foot guards.		
	115.	☐	Top ladder tread is between 12 inches and 18 inches below the mounting surface of the outboard end of the adjacent roof handhold.	5.11.2.3	
	116.	☐	Maximum spacing between ladder treads, 19 inches.		
	117.	☐	Spacing of side ladder treads is uniform within a limit of 2 inches, from top ladder tread to bottom tread of ladder.		
Elective Safety Appliance - Roof Handhold	118.	☐	Minimum diameter, 5/8 inch.	5.11.3.2	
	119.	☐	Minimum clear length, 16 inches.		
	120.	☐	Minimum clearance, 2 inches.		
	121.	☐	Securely fastened to the carbody structure.	4.4	
	122.	☐	Welds done in accordance with the standard and with proper welding procedures.		

Elective Safety Appliance - Roof Handhold Continued	123.	☐	If roof handholds are located above a ladder, in the transverse direction, clearance points of the inboard end of roof handholds are maximum 8 inches inboard from and no further outboard than the clearance point of the inboard end of the top ladder tread.	5.11.3.3	

Safety Appliance Standards
Comparison of APTA SS-M-016-06 to 49 CFR 231 & 238

Code of Federal Regulations	APTA SS-M-016-06	Justification	Status
49 CFR 231.12 Passenger-train cars with wide vestibules.	N/A	APTA SS-M-016-06 defines safety appliances by function rather than by location or by car configuration. 49 CFR 231 contains three different passenger car types in parts 231.12 (wide vestibules), 231.13 (open-end platforms) and 231.14 (without end platforms). Modern equipment designs do not follow these specific car configurations. The passenger railroads have introduced multiple level cars, cars with center boarding, cab cars, etc. The APTA standard was developed to provide clarity in the design, fabrication and installation of safety appliances on modern designs of passenger cars. The standard clearly defines the function of each type of safety appliance and gives detailed requirements on the dimensions, material, location and manner of attachment.	Improvement
49 CFR 231.12(a)(1) Hand brakes--(1) Number. Each passenger-train car shall be equipped with an efficient hand brake, which shall operate in harmony with the power brake thereon.	*Section 5.1.1* Except as provided in Section 6, each car shall have a handbrake or parking brake that complies with APTA SS-M-006-98, Rev. 1, and that operates in harmony with the power brake equipment on the car. If a parking brake is used, it shall be capable of being set from each car, and each car shall be equipped with a means to release the parking brake manually.	N/A	No change
49 CFR 231.12(a)(2) Location. Each hand brake shall be so located that it can be safely operated while car is in motion.	*Section 5.1.3.1* a) The handbrake as installed, whether applied or released, and in its stored position shall be	Part 231 and SS-M-016-06 both require that the handbrake be located so that it can be operated safely while the car is in motion. SS-M-016-06 further provides a greater degree of safety by	Improvement

Code of Federal Regulations	APTA SS-M-016-06	Justification	Status
	located so as to not restrict passenger flow through any passageway. b) The handbrake shall be located so it can be safely operated while the car is in motion. c) A handhold shall be provided to stabilize an employee when using the handbrake. d) The center point of the wheel or the pivot point of the lever used to apply the handbrake shall be located 31 to 40 inches (787 to 1016 mm) above the floor. *Section 5.1.3.2* a) Any handbrake handle retention mechanism shall not interfere with the normal grip position of the lever. b) The handbrake lever shall have a minimum 2 inch (51 mm) hand clearance in the stored position. The handbrake lever shall have a minimum 24 inch (610 mm) body clearance on one side of the lever and a minimum 4 inch (102 mm) hand clearance on the opposite side and end in the operating position. c) The clearance between the grip portion of the release lever, if used, and any part of the car shall be no less than 2.5 inches (64 mm).	requiring that the handbrake not obstruct any passageway and provides design requirements for the mounting hardware and clearances.	

Code of Federal Regulations	APTA SS-M-016-06	Justification	Status
	Section 5.1.3.3 a) The wheel type handbrake shall have a minimum 4 inch (102 mm) hand clearance. b) The wheel diameter shall be at least 22 inches (559 mm).		
49 CFR 231.12(b)(1) (b) Side handholds--(1) Number. Eight.	*Section 5.6.1* Except as provided in Section 6, on cars with passenger entrances with the lowest step at a height of 24 inches ATR or less, crew handholds shall be applied above at least one passenger entrance per car side. *Section 5.6.4* a) There shall be two vertical crew handholds, one on each side of the door opening.	APTA SS-M-016-06 defines safety appliances by function rather than by location or by car configuration. The standard requires 2 vertical handholds to be applied above at least one passenger entrance per car side, one on each side of the door opening. These handholds are used to assist an employee while entering or leaving a car at passenger entrances 24 inches ATR or less. If the passenger step is to be used in lieu of a sill step, then 2 handholds must be applied above the step. This meets the intent of Part 231 which requires one handhold on each vestibule door post.	Deviation
49 CFR 231.12(b)(2) Dimensions. Minimum diameter, five-eighths of an inch, metal. Minimum clear length, 16 inches. Minimum clearance, 1-1/4, preferably 1-1/2 inches.	*Section 5.6.3* Handholds shall be no less than 5/8 inch (16 mm) diameter. Minimum clear length of vertical handholds shall be 33 inches (838 mm). Minimum clearance shall be 2 inches (51 mm), preferably 2.5 inches (64 mm).	Part 231.12(b)(2) requires a minimum handhold clearance of 1-1/4, preferably 1-1/2 inches, and a minimum clear length of 16 inches. SS-M-016-06 requires a minimum clearance of 2 inches, preferably 2.5 inches, and a minimum clear length of 33 inches. APTA believes that this provides a greater deal of safety than do the requirements of Part 231.	Improvement

Code of Federal Regulations	APTA SS-M-016-06	Justification	Status
49 CFR 231.12(b)(3) Location. Vertical, one on each vestibule door post.	*Section 5.6.4* a) There shall be two vertical crew handholds, one on each side of the door opening. b) The lowest clearance point of each crew handhold shall be at most 54 inches (1372 mm) ATR. c) If the crew handhold is located outside of the door opening, the crew handhold shall be located no more than 6 inches from the vertical inside face of the door opening.	Part 231.12(b)(3) requires one handhold to be applied vertically on each vestibule door post. SS-M-016-06 requires 2 vertical handholds, one on each side of the door opening. SS-M-016-06 further specifies the location of each handhold to provide an ergonomic means for the 5th percentile female and 95th percentile male to use the handhold.	Improvement
49 CFR 231.12(b)(4) Manner of application. Side handholds shall be securely fastened with bolts, rivets, or screws.	*Section 4.4* a) All safety appliances shall be securely fastened to the carbody structure.	Both Part 231.12(b)(4) and SS-M-016-06 require handholds to be securely fastened to the carbody structure.	No change
49 CFR 231.12(c)(1) (b) Side handholds--(1) Number. Eight.	*Section 5.7.1* Except as provided in Section 6, two end handholds shall be on each end of the car.	Both Part 231.12(b)(4) and SS-M-016-06 require 4 end handholds.	No change
49 CFR 231.12(c)(2)(i) Dimensions. (i) Minimum diameters, five-eighths of an inch, wrought iron or steel. Minimum clear length, 16 inches. Minimum clearance, 2, preferably 2-1/2 inches.	*Section 5.7.3* Handholds shall be no less than 5/8 inch (16 mm) diameter. Minimum clear length of end handholds shall be 16 inches (406 mm). Minimum clearance shall be 2 inches (51 mm), preferably 2.5 inches (64 mm), with end connections applied and end receptacle covers in resting position.	Both Part 231.12(b)(4) and SS-M-016-06 require minimum diameters of 5/8 inch, minimum clear length of 16 inches and minimum clearance of 2, preferably 2-1/2 inches. SS-M-016-06 further specifies that the minimum clearance shall be measured with end connections applied and end receptacle covers in resting position.	Improvement
49 CFR 231.12(c)(2)(ii) (ii) Handholds shall be flush with or project not more	*Section 5.7.4* End handholds shall be oriented horizontally, one near	Part 231 requires that handholds be flush with or not project more than 1 inch beyond the face of the end	Deviation

Code of Federal Regulations	**APTA SS-M-016-06**	**Justification**	**Status**
than 1 inch beyond vestibule face.	each side on each end projecting from the face of the end sill or sheathing. The clearance point of the outboard end of the end handhold shall be not more than 16 inches (406 mm) from side of car.	sill. SS-M-016-06 requires end handholds to project from the face of the end sill or sheathing. APTA believes that this provides the best method to locate the end handholds on the car.	
49 CFR 231.12(c)(3) Location. Horizontal, one near each side on each end projecting downward from face of vestibule end sill. Clearance of outer end of handhold shall be not more than 16 inches from side of car.	*Section 5.7.4* End handholds shall be oriented horizontally, one near each side on each end projecting from the face of the end sill or sheathing. The clearance point of the outboard end of the end handhold shall be not more than 16 inches (406 mm) from side of car.	Both Part 231.12(b)(4) and SS-M-016-06 require end handholds to be located horizontally, one near each side on each end projecting downward from face of vestibule end sill. Clearance of outer end of handhold shall be not more than 16 inches from side of car.	No change
49 CFR 231.12(c)(4) Manner of application. End handholds shall be securely fastened with bolts or rivets. When marker sockets or brackets are located so that they can not be conveniently reached from platforms, suitable steps and handholds shall be provided for men to reach such sockets or brackets.	*Section 4.4* a) All safety appliances shall be securely fastened to the carbody structure. *Section 5.11.1* When marker sockets or brackets are located so that they cannot be conveniently reached from platforms, suitable steps and handholds shall be provided for employees to reach such sockets or brackets. These steps and handholds shall follow the requirements for side door steps and side door handholds respectively. Alternately, the requirements for ladders may be used.	Both Part 231.12(c)(4) and SS-M-016-06 require end handholds to be securely fastened to the carbody structure. Both documents also require that suitable steps and handholds shall be provided for employees to reach marker sockets or brackets.	No change
49 CFR 231.12(d)(1) Uncoupling levers. (1) Uncoupling attachments shall be applied so they can be operated by a person standing on the ground.	*Section 5.10.1* Except as provided in Section 6, each car shall have either a mechanical uncoupling device at each end of the car or an uncoupling mechanism operated by controls located in a secure location in the car. *Section 5.10.3*	Part 231.12(d)(1) requires uncoupling attachments to be applied so they can be operated by a person standing on the ground. SS-M-016-06 requires either a mechanical uncoupling device at each end of the car for a mechanical coupler or an uncoupling mechanism	Improvement

Code of Federal Regulations	**APTA SS-M-016-06**	**Justification**	**Status**
	b) Uncoupling attachments shall be applied so they can be operated by a person standing on the ground.	operated by controls located in a secure location in the car for an automatic coupler. SS-M-016-06 also requires uncoupling attachments to be applied so they can be operated by a person standing on the ground.	
49 CFR 231.12(d)(2) Minimum length of ground uncoupling attachment, 42 inches, measured from center line of end of car to handle of attachment.	*Section 5.10.3* If the uncoupling device is mechanically operated from the side of the car, the following shall apply: a) Under all operating conditions, the outside surface of the uncoupling device handles shall be no more than 14 inches (356 mm) closer to the car center than the inside surface of the adjacent side handhold. See Figure 17. b) Uncoupling attachments shall be applied so they can be operated by a person standing on the ground. c) The bottom end of the handle shall be no less than 12 inches (305 mm) and no more than 15 inches (381 mm) below the centerline of the outermost pivot point of the uncoupling lever to which the handle is attached. d) The end of handle shall be constructed to provide a minimum 2 inches (51 mm) clearance around the handle.	The dimensioning system used in SS-M-016-06 better defines the relationship between the uncoupling device and the distance to the side of the car from which a person would be operating the device. It is also easier to measure and determine compliance on some cars.	Improvement
49 CFR 231.12(d)(3)	*Section 5.10.4*	Both Part 231.12(d)(3) and SS-M-016-06 require	No change

Safety Appliance Standards
Comparison of APTA SS-M-016-06 to 49 CFR 231 & 238

Code of Federal Regulations	APTA SS-M-016-06	Justification	Status
On passenger-train cars used in freight or mixed-train service, the uncoupling attachment shall be so applied that the coupler can be operated from left side of car.	When used, the uncoupling levers shall be so applied that the coupler can be operated from the left side of the car as seen when facing the end of the car from the ground.	the uncoupling attachment to be so applied that the coupler can be operated from left side of car.	
49 CFR 231.13 Passenger-train cars with open-end platforms.	N/A	APTA SS-M-016-06 defines safety appliances by function rather than by location or by car configuration. 49 CFR 231 contains three different passenger car types in parts 231.12 (wide vestibules), 231.13 (open-end platforms) and 231.14 (without end platforms). Modern equipment designs do not follow these specific car configurations. The passenger railroads have introduced multiple level cars, cars with center boarding, cab cars, etc. The APTA standard was developed to provide clarity in the design, fabrication and installation of safety appliances on modern designs of passenger cars. The standard clearly defines the function of each type of safety appliance and gives detailed requirements on the dimensions, material, location and manner of attachment.	Improvement
49 CFR 231.13(a)(1) Hand brakes--(1) Number. Each passenger-train car shall be equipped with an efficient hand brake, which shall operate in harmony with the power brake thereon.	*Section 5.1.1* Except as provided in Section 6, each car shall have a handbrake or parking brake that complies with APTA SS-M-006-98, Rev. 1, and that operates in harmony with the power brake equipment on the car. If a parking brake is used, it shall be capable of being set from each car, and each car shall be equipped with a means to release the parking brake manually.	N/A	No change

Code of Federal Regulations	**APTA SS-M-016-06**	**Justification**	**Status**
49 CFR 231.13(a)(2) Location. Each hand brake shall be so located that it can be safely operated while car is in motion.	*Section 5.1.3.1* a) The handbrake as installed, whether applied or released, and in its stored position shall be located so as to not restrict passenger flow through any passageway. b) The handbrake shall be located so it can be safely operated while the car is in motion. c) A handhold shall be provided to stabilize an employee when using the handbrake. d) The center point of the wheel or the pivot point of the lever used to apply the handbrake shall be located 31 to 40 inches (787 to 1016 mm) above the floor. *Section 5.1.3.2* a) Any handbrake handle retention mechanism shall not interfere with the normal grip position of the lever. b) The handbrake lever shall have a minimum 2 inch (51 mm) hand clearance in the stored position. The handbrake lever shall have a minimum 24 inch (610 mm) body clearance on one side of the lever and a minimum 4 inch (102 mm) hand clearance on the opposite side and end in the operating position.	Part 231 and SS-M-016-06 both require that the handbrake be located so that it can be operated safely while the car is in motion. SS-M-016-06 further provides a greater degree of safety by requiring that the handbrake not obstruct any passageway and provides design requirements for the mounting hardware and clearances.	Improvement

Code of Federal Regulations	APTA SS-M-016-06	Justification	Status
	c) The clearance between the grip portion of the release lever, if used, and any part of the car shall be no less than 2.5 inches (64 mm). *Section 5.1.3.3* a) The wheel type handbrake shall have a minimum 4 inch (102 mm) hand clearance. b) The wheel diameter shall be at least 22 inches (559 mm).		
49 CFR 231.13(b)(1) End handholds--(1) Number. Four.	*Section 5.7.1* Except as provided in Section 6, two end handholds shall be on each end of the car.	Both Part 231.12(b)(4) and SS-M-016-06 require 4 end handholds.	No change
49 CFR 231.13(b)(2) Dimensions. Minimum diameter, five-eighths of an inch, wrought iron or steel. Minimum clear length, 16 inches. Minimum clearance, 2, preferably 2-1/2 inches. Handholds shall be flush with or project not more than 1 inch beyond surface of end sill.	*Sections 5.7.3 & 5.7.4* Handholds shall be no less than 5/8 inch (16 mm) diameter. Minimum clear length of end handholds shall be 16 inches (406 mm). Minimum clearance shall be 2 inches (51 mm), preferably 2.5 inches (64 mm), with end connections applied and end receptacle covers in resting position. End handholds shall be oriented horizontally, one near each side on each end projecting from the face of the end sill or sheathing. The clearance point of the outboard end of the end handhold shall be not more than 16 inches (406 mm) from side of car.	Both Part 231.12(b)(4) and SS-M-016-06 require minimum diameters of 5/8 inch, minimum clear length of 16 inches and minimum clearance of 2, preferably 2-1/2 inches. SS-M-016-06 further specifies that the minimum clearance shall be measured with end connections applied and end receptacle covers in resting position. Part 231 requires that handholds be flush with or not project more than 1 inch beyond the face of the end sill. SS-M-016-06 requires end handholds to project from the face of the end sill or sheathing. APTA believes that this provides the best method to locate the end handholds on the car.	Deviation

Safety Appliance Standards
Comparison of APTA SS-M-016-06 to 49 CFR 231 & 238

Code of Federal Regulations	APTA SS-M-016-06	Justification	Status
49 CFR 231.13(b)(3) Location. Horizontal, one near each side of each end on face of platform end sill, projecting downward. Clearance of outer end of handhold shall be not more than 16 inches from end of end sill.	*Section 5.7.4* End handholds shall be oriented horizontally, one near each side on each end projecting from the face of the end sill or sheathing. The clearance point of the outboard end of the end handhold shall be not more than 16 inches (406 mm) from side of car.	Both Part 231.12(b)(4) and SS-M-016-06 require end handholds to be located horizontally, one near each side on each end projecting downward from face of vestibule end sill. Clearance of outer end of handhold shall be not more than 16 inches from side of car.	No change
49 CFR 231.13(b)(4) Manner of application. End-handholds shall be securely fastened with bolts or rivets.	*Section 4.4* a) All safety appliances shall be securely fastened to the carbody structure.	Both Part 231.12(c)(4) and SS-M-016-06 require end handholds to be securely fastened to the carbody structure.	No change
49 CFR 231.13(c)(1) End-platform handholds--(1) Number. Four. (Cars equipped with safety gates do not require end-platform handholds.)	*Section 5.9.1* Open platform cars shall have the platform area enclosed with either a handrail or shortened walls. *Section 5.9.2* A handrail or a shortened wall is used on open platform cars to enclose the platform area and stabilize an employee standing on the open platform.	End platform handholds and handrails are specified in Part 231 for cars with open-end platforms and cars without end platforms. SS-M-016-06 does not include provisions for handrails on open platform cars. A specific number of handholds are not required but the standard does require that a handrail or shortened wall be used to enclose the platform and stabilize an employee standing on the open platform.	Deviation
49 CFR 231.13(c)(2) Dimensions. Minimum clearance, 2, preferably 2-1/2 inches, metal.	*Section 5.9.3* Handrails shall be no less than 1 inch (25.5 mm) diameter tubing with a minimum wall thickness of 1/16 inch (1.6 mm).	Part 231 requires a minimum clearance of 2, preferably 2-1/2, inches. SS-M-016-06 requires that handrails have no less than 1 inch (25.5 mm) diameter tubing with a minimum wall thickness of 1/16 inch (1.6 mm).	Deviation
49 CFR 231.13(c)(3) Location. Horizontal from or near door post to a point not more than 12 inches from corner of car, then approximately vertical to a point not more than 6 inches from top of platform. Horizontal portion shall be not	*Section 5.9.4* a) Open platform cars shall have the platform area enclosed with either a handrail or shortened walls. The handrail may be continuous or may be intermittent to extend between other members of the	SS-M-016-06 provides greater details on the location of handrails on open platforms.	Deviation

Code of Federal Regulations	APTA SS-M-016-06	Justification	Status
less than 24 inches in length nor more than 40 inches above platform.	car such as collision posts and corner posts. b) If an intermittent handrail is used, the end of the handrail shall be capped with a rounded end to reduce risk of injury. c) The distance from the end of the handrail to a vertical car member shall not exceed 4 inches (102 mm). d) The handrail shall be at least 42 inches (1071 mm) from the top of the platform floor to the top of the handrail, including entry doors. e) The handrail arrangement shall be designed such that a 5 inch (127.5 mm) diameter ball cannot pass through any space between handrail members or between the handrail and the carbody. f) Handrail members shall not be unsupported for spans over 48 inches (1224 mm). g) The railing and stile assembly may be welded but the ends of the final assembly must be securely fastened to the car structure. h) If a shortened wall is used, it shall meet the location requirement for handrails as detailed in items a) through g) above.		

Safety Appliance Standards
Comparison of APTA SS-M-016-06 to 49 CFR 231 & 238

Code of Federal Regulations	APTA SS-M-016-06	Justification	Status
49 CFR 231.13(c)(4) Manner of application. End-platform handholds shall be securely fastened with bolts, rivets, or screws.	*Section 4.4* a) All safety appliances shall be securely fastened to the carbody structure.	Both Part 231.12(b)(4) and SS-M-016-06 require handrails to be securely fastened to the carbody structure.	No change
49 CFR 231.13(d)(1) Uncoupling levers. (1) Uncoupling attachments shall be applied so they can be operated by a person standing on the ground.	*Section 5.10.1* Except as provided in Section 6, each car shall have either a mechanical uncoupling device at each end of the car or an uncoupling mechanism operated by controls located in a secure location in the car. *Section 5.10.3* b) Uncoupling attachments shall be applied so they can be operated by a person standing on the ground.	Part 231.12(d)(1) requires uncoupling attachments to be applied so they can be operated by a person standing on the ground. SS-M-016-06 requires either a mechanical uncoupling device at each end of the car for a mechanical coupler or an uncoupling mechanism operated by controls located in a secure location in the car for a powered coupler. SS-M-016-06 also requires uncoupling attachments to be applied so they can be operated by a person standing on the ground.	Improvement
49 CFR 231.13(d)(2) Minimum length of ground uncoupling attachment, 42 inches, measured from center of end of car to handle of attachment.	*Section 5.10.3* If the uncoupling device is mechanically operated from the side of the car, the following shall apply: a) Under all operating conditions, the outside surface of the uncoupling device handles shall be no more than 14 inches (356 mm) closer to the car center than the inside surface of the adjacent side handhold. See Figure 17. b) Uncoupling attachments shall be applied so they can be operated by a person standing on the ground.	The dimensioning system used in SS-M-016-06 better defines the relationship between the uncoupling device and the distance to the side of the car from which a person would be operating the device. It is also easier to measure and determine compliance on some cars.	Improvement

Code of Federal Regulations	APTA SS-M-016-06	Justification	Status
	c) The bottom end of the handle shall be no less than 12 inches (305 mm) and no more than 15 inches (381 mm) below the centerline of the outermost pivot point of the uncoupling lever to which the handle is attached. d) The end of handle shall be constructed to provide a minimum 2 inches (51 mm) clearance around the handle.		
49 CFR 231.13(d)(3) On passenger-train cars used in freight or mixed-train service the uncoupling attachments shall be so applied that the coupler can be operated from left side of car.	*Section 5.10.4* When used, the uncoupling levers shall be so applied that the coupler can be operated from the left side of the car as seen when facing the end of the car from the ground.	Both Part 231.12(d)(3) and SS-M-016-06 require the uncoupling attachment to be so applied that the coupler can be operated from left side of car.	No change
49 CFR 231.14(a)(1) Handbrakes--(1) Number. Each passenger-train car shall be equipped with an efficient hand brake which shall operate in harmony with the power brake thereon.	*Section 5.1.1* Except as provided in Section 6, each car shall have a handbrake or parking brake that complies with APTA SS-M-006-98, Rev. 1, and that operates in harmony with the power brake equipment on the car. If a parking brake is used, it shall be capable of being set from each car, and each car shall be equipped with a means to release the parking brake manually.	N/A	No change
49 CFR 231.14(a)(2) Location. Each hand brake shall be so located that it can be safely operated while car is in motion.	*Section 5.1.3.1* a) The handbrake as installed, whether applied or released, and in its stored position shall be located so as to not restrict passenger flow through any	Part 231 and SS-M-016-06 both require that the handbrake be located so that it can be operated safely while the car is in motion. SS-M-016-06 further provides a greater degree of safety by requiring that the handbrake not obstruct any passageway and provides design requirements for	Improvement

Code of Federal Regulations	APTA SS-M-016-06	Justification	Status
	passageway. b) The handbrake shall be located so it can be safely operated while the car is in motion. c) A handhold shall be provided to stabilize an employee when using the handbrake. d) The center point of the wheel or the pivot point of the lever used to apply the handbrake shall be located 31 to 40 inches (787 to 1016 mm) above the floor. *Section 5.1.3.2* a) Any handbrake handle retention mechanism shall not interfere with the normal grip position of the lever. b) The handbrake lever shall have a minimum 2 inch (51 mm) hand clearance in the stored position. The handbrake lever shall have a minimum 24 inch (610 mm) body clearance on one side of the lever and a minimum 4 inch (102 mm) hand clearance on the opposite side and end in the operating position. c) The clearance between the grip portion of the release lever, if used, and any part of the car shall be no less than 2.5 inches (64 mm).	the mounting hardware and clearances.	

Code of Federal Regulations	APTA SS-M-016-06	Justification	Status
	Section 5.1.3.3 a) The wheel type handbrake shall have a minimum 4 inch (102 mm) hand clearance. b) The wheel diameter shall be at least 22 inches (559 mm).		
49 CFR 231.14(b)(1) Sill steps--(1) Number. Four.	*Section 5.2.1* Except as provided in Section 6, each car shall have a sill step applied at each corner of the car where no useable passenger step is available.	Part 231 requires 4 sill steps per car. SS-M-016-06 requires either a sill step or a useable passenger step at each corner of the car. This enables a passenger step to be used in lieu of a sill step where possible. SS-M-016-06 requires a sill step and two corresponding handholds an ergonomically correct distance apart for all new equipment. If a railroad wishes to procure new equipment designs where placement of two handholds above the sill step is not possible, that railroad may do so if it adopts an operating practice that prohibits riding that sill step. This new requirement accomplishes two important things: 1) for new equipment, railroad employees are provided the extra safety of a second handhold, or they are not allowed to expose themselves to the danger of riding a sill step equipped with only one handhold; and 2) railroads can continue to purchase equipment designs with corner doors.	Improvement

Code of Federal Regulations	APTA SS-M-016-06	Justification	Status
49 CFR 231.14(b)(2) Dimensions. Minimum length of tread, 10, preferably 12, inches. Minimum cross-sectional area, 1/2 by 1-1/2 inches or equivalent, wrought iron or steel. Minimum clear depth, 8 inches.	*Section 5.2.3* a) The minimum useable length of tread shall be not less than 12 inches (305 mm). b) Sill steps shall be no less than 1/2 inch (13 mm) thick and no less than 2 inches (51 mm) wide. Alternate material sections may be used if they maintain the equivalent strength and rigidity of a 1/2 inch (13 mm) by 2 inch (51 mm) width step. Tread width shall be maintained at a 2 inch (51 mm) minimum. c) The clear depth above the entire useable length of the sill step tread shall be no less than 8 inches (203 mm) and the clear width of all sill step treads shall be no less than 6 inches (152 mm) with the trucks rotated to simulate the maximum curvature specified for the uncoupled car. d) To account for minor deviations, the application of sill steps shall be such that a box with the following dimensions can pass through the opening above the sill step to the point where the box is flush with the outer edge of the step. See Figure 3.	SS-M-016-06 requires that the sill step have a minimum tread length of 12 inches, whereas Part 231 permits a 10 inch tread. Part 231 would permit sill steps thinner than 1/2 inch if the width is increased to provide the same cross sectional area as a 1/2 inch thick by 1-1/2 inch wide step. Such a step would be less stiff and provide less support than the nominal 1/2 inch by 1-1/2 inch step. In addition to requiring that the step be 1/2 inch thick regardless of its width, SS-M-016-06 also requires that it be no less than 2 inches wide, rather than 1-1/2 inches wide. This represents a noticeable increase in sill step stiffness and the wider step is also more comfortable to the foot when supporting a person's weight. Both Part 231 and SS-M-016-06 require a clear depth of 8 inches.	Improvement
49 CFR 231.14(b)(3)(i) Location. (i) One near each end on each side not more than 24 inches from corner of car to center of tread of sill step.	*Section 5.2.4* a) One sill step shall be applied at each corner of the car. A passenger step may be used in lieu of a sill	Part 231 requires one sill step near each end on each side not more than 24" from the corner of the car to the center of the step. SS-M-016-06 requires either a sill step or a useable passenger step at each corner	Improvement

Code of Federal Regulations	APTA SS-M-016-06	Justification	Status
	step if it meets the clear depth, clear width, useable length and location requirements for a sill step. b) The outboard edge of the sill step shall be not more than 18 inches (457 mm) in the longitudinal direction from the corner of the car. For cars without well-defined corners, the intent is for the sill step to be positioned for the employee to have an unobstructed view of the track ahead. The sill step shall be placed so the employee has a clear view both in both longitudinal directions and shall be placed outside the gauge of the track.	of the car. This enables a passenger step to be used in lieu of a sill step where possible. SS-M-016-06 further defines the distance from the corner of the car to the outboard edge of the sill step for ease of measurement. It also clarifies the intent of the standard for cars without well-defined corners.	
49 CFR 231.14(b)(3)(ii) Outside edge of tread of step shall be not more than 2 inches inside of face of side of car.	*Section 5.2.4* e) The design goal is to have the outside edge of the tread of the sill step as close to being flush with the side of the car as the clearance diagram permits. To align sill step width with respect to handholds, in the transverse direction, the outside edge of any sill step tread shall not be more than 4 inches (102 mm) inboard or outboard of the inside surface of the lowest adjacent side handhold. In addition, the outside edge of any sill step tread shall be no more than 2 inches (51 mm) inboard of any car structure below the lowest adjacent side handhold in the area from the inboard clearance point of the handhold to the outboard vertical leg of the sill step. If the clearance diagram of the railroad does not allow this 2 inch requirement to be achieved, up to 4 inches	Both Part 231 and SS-M-016-06 require the outside edge of tread of step shall be not more than 2 inches inside of face of side of car. SS-M-016-06 further clarifies that the outside edge of any sill step tread be no more than 2 inches inboard of any car structure below the lowest adjacent side handhold. This defines the sill step tread in relation to both its corresponding handhold and the car structure. Note that SS-M-016-06 also states that if the clearance diagram of the railroad does not allow this 2 inch requirement to be achieved, up to 4 inches may be allowed provided the sill step tread is no more than 21 inches above the top of rail.	Deviation

Code of Federal Regulations	APTA SS-M-016-06	Justification	Status
	(102 mm) may be allowed provided the sill step tread is no more than 21 inches above the top of rail.		
49 CFR 231.14(b)(3)(iii) Tread shall be not more than 24, preferably not more than 22, inches above the top of rail.	*Section 5.2.4* d) The design goal is to have the tread of the sill step as close to the top of rail as the clearance diagram permits. The sill step tread shall be not more than 24 inches (610 mm), preferably not more than 22 inches (560 mm), above the top of rail.	Both Part 231 and SS-M-016-06 require the sill step tread to be not more than 24", preferably not more than 22", above top of rail.	No change
49 CFR 231.14(b)(4)(i) Manner of application. (i) Steps exceeding 18 inches in depth shall have an additional tread and be laterally braced.	*Section 5.2.4* c) Steps exceeding 18 inches (457 mm) in depth shall be transversely braced or equivalent.	Both Part 231 and SS-M-016-06 require steps exceeding 18 inches in depth to be transversely braced. APTA requires transversely braced *or equivalent*. APTA does not require an additional tread.	Deviation
49 CFR 231.14(b)(4)(ii) Sill steps shall be securely fastened with not less than 1/2-inch bolts with nuts outside (when possible) and riveted over, or with not less than 1/2-inch rivets.	*Section 4.4* a) All safety appliances shall be securely fastened to the carbody structure.	Both Part 231.12(b)(4) and SS-M-016-06 require sill steps to be securely fastened to the carbody structure.	No change
49 CFR 231.14(c)(1) Side handholds--(1) Number. Four.	*Section 5.4.4* a) There shall be a minimum of two handholds over each sill step. If it is not possible to place two handholds over a sill step, there shall be one handhold over that sill step and the railroad shall prohibit employees from riding on that sill step. **Note:** When only one sill step handhold is used, APTA recommends that a "DO NOT RIDE" sign be affixed to the car above the sill step.	Part 231.14(c)(1) requires 4 side handholds per car. SS-M-016-06 requires a minimum of 2 handholds over each sill step. If it is not possible to place 2 handholds over a sill step, it requires one handhold over that sill step and requires the railroad to prohibit employees from riding on that sill step. The APTA working group that developed this safety appliance standard for passenger rail cars included an ergonomics professional. The ergonomics	Improvement

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		professional advised APTA that riding a sill step when holding on to a single handhold is difficult in some operating circumstances. As a result, the standard requires two handholds placed an ergonomically acceptable distance apart above each sill step on new cars. This caused controversy because many car designs have doors near the corner of the car that would preclude the placement of the second handhold an ergonomically acceptable distance from the first handhold. Some passenger railroads currently prohibit their employees from riding sill steps because they believe the employees are safer riding inside the car or walking beside the car during switching moves. APTA surveyed 18 passenger railroads; 16 of them either currently have operating rules that prohibit riding sill steps or strongly discourage riding sill steps and would be willing to implement such an operating practice. As a result of this survey, APTA considered an option to eliminate sill steps if the railroad has in place an operating practice that prohibits their use. The best way to enforce this operating practice is to eliminate the sill step. Employees cannot use what is not there. This solves the door-near-the-corner-	

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		of-the-car design problem. If a railroad wishes to operate equipment of this design, that railroad must either ban riding the sill step or determine a way to install a second handhold above the sill step an ergonomically correct distance from the first handhold. Neither the FRA nor the rail labor representatives to the working group supported this APTA proposal to make sill steps an option on future passenger cars. As a result of this lack of support, APTA modified the proposal. The standard now requires a sill step and two corresponding handholds an ergonomically correct distance apart for all new equipment. If a railroad wishes to procure new equipment designs where placement of two handholds above the sill step is not possible, that railroad may do so if it adopts an operating practice that prohibits riding that sill step. This new requirement accomplishes two important things: 1) for new equipment, railroad employees are provided the extra safety of a second handhold or they are not allowed to expose themselves to the danger of riding a sill step equipped with only one handhold; and 2) railroads can continue to purchase equipment designs with corner doors.	

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		As with all compromises, the new requirement has a downside. A sill step with a single handhold must be provided even when the railroad bans riding the sill step. From a railroad's perspective, this does not make sense. But it gained the FRA and labor support necessary for APTA to go forward. This compromise answers labor's concern over the interchange of equipment without sill steps between passenger railroads and over hauling such passenger cars in freight trains. Overall safety of railroad employees will increase with time as more cars with two handholds above sill steps enter the fleet.	
49 CFR 231.14(c)(2) Dimensions. Minimum diameter, five-eighths of an inch, wrought iron or steel. Minimum clear length, 16, preferably 24, inches. Minimum clearance, 2, preferably 2-1/2, inches.	*Section 5.4.3* Handholds shall be no less than 5/8 inch (16 mm) diameter. Minimum clear length of handholds shall be 16 inches (406 mm). Minimum clearance shall be 2 inches (51 mm), preferably 2.5 inches (64 mm).	Both Part 231 and SS-M-016-06 require the same minimum diameter, clear length and clearance of handholds.	No change
49 CFR 231.14(c)(3) Location. Horizontal or vertical, one near each end on each side of car over sill step. (i) If horizontal, not less than 24 nor more than 30 inches above center line of coupler. (ii) If vertical, lower end not less than 18 nor more than 24 inches above center line of coupler.	*Section 5.4.4* a) There shall be a minimum of two handholds over each sill step. If it is not possible to place two handholds over a sill step, there shall be one handhold over that sill step and the railroad shall prohibit employees from riding on that sill step. **Note:** When only one sill step handhold is used, APTA recommends that a "DO NOT RIDE" sign be affixed to the car above the sill step. b) When at least two horizontal handholds are used, one	Part 231.14(c)(3) requires 1 handhold over each sill step. SS-M-016-06 requires a minimum of 2 handholds over each sill step. If it is not possible to place 2 handholds over a sill step, it requires one handhold over that sill step and requires the railroad to prohibit employees from riding on that sill step. For further information on the justification for this item, see the justification above regarding number of side handholds. Although SS-M-016-06 doesn't specifically meet	Deviation

Code of Federal Regulations	APTA SS-M-016-06	Justification	Status
	horizontal handhold shall be at most 54 inches (1372 mm) ATR. The second horizontal handhold shall be 54 to 58 inches (1372 to 1473 mm) above the step. See Figure 9. c) When one horizontal handhold is used, it shall be 54 to 56 inches (1372 to 1473 mm) ATR. See Figure 10. d) Twelve inches (305 mm) of the clear length of the horizontal handhold shall be directly over the sill step. See Figure 9. e) When at least two vertical handholds are used, the lowest clearance point of each vertical handhold shall be at most 54 inches (1372 mm) ATR. The highest clearance point of each vertical handhold shall be at least 58 inches (1473 mm) above the step. Each set of vertical handholds shall be spaced not less than 16 inches (406 mm) nor more than 22 inches (559 mm) apart. See Figure 11. f) When one vertical handhold is used, its lowest clearance point shall be at most 54 inches (1372 mm) ATR. Its highest clearance point shall be at least 70 inches (1778 mm) ATR. See Figure 12. The handhold shall be located above the clear length of the step.	the dimensional requirements of Part 231.14(c)(3), the better ergonomics are an improvement to the CFR requirements.	

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	g) To align vertical handholds with the sill steps, the handholds shall be located in the longitudinal direction such that the inside face of the outboard handhold is no more than 2 inches (51 mm) outboard of the inside face of the outboard vertical leg of the step and is no less than 10 inches (254 mm) outboard from the inside face of the inboard vertical leg. See Figure 11. h) When a combination of horizontal and vertical handholds are used, the horizontal handhold shall be 54 to 58 inches (1372 to 1473 mm) above the step. The lowest clearance point of the vertical handhold shall be at most 54 inches (1372 mm) ATR. The highest clearance point of the vertical handhold shall be at least 70 inches (1778 mm) ATR. See Figure 13. One continuous handhold may be used as long as it meets the dimensional requirements of this paragraph.		
49 CFR 231.14(c)(4) Manner of application. Side handholds shall be securely fastened with bolts, rivets or screws.	*Section 4.4* a) All safety appliances shall be securely fastened to the carbody structure.	Both Part 231.12(b)(4) and SS-M-016-06 require handholds to be securely fastened to the carbody structure.	No change
49 CFR 231.14(d)(1) End handholds--(1) Number. Four.	*Section 5.7.1* Except as provided in Section 6, two end handholds shall be on each end of the car.	Both Part 231.12(b)(4) and SS-M-016-06 require 4 end handholds.	No change
49 CFR 231.14(d)(2) Dimensions. Minimum diameter, five-eighths of an inch, wrought iron or steel. Minimum clear length, 16	*Section 5.7.3* Handholds shall be no less than 5/8 inch (16 mm) diameter. Minimum clear length of end handholds	Both Part 231.12(b)(4) and SS-M-016-06 require minimum diameters of 5/8 inch, minimum clear length of 16 inches and minimum clearance of 2,	Improvement

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inches. Minimum clearance, 2, preferably 2-1/2, inches.	shall be 16 inches (406 mm). Minimum clearance shall be 2 inches (51 mm), preferably 2.5 inches (64 mm), with end connections applied and end receptacle covers in resting position.	preferably 2-1/2 inches. SS-M-016-06 further specifies that the minimum clearance shall be measured with end connections applied and end receptacle covers in resting position.	
49 CFR 231.14(d)(3) Location. Horizontal, one near each side on each end projecting downward from face of end sill or sheathing. Clearance of outer end of handholds shall be not more than 16 inches from side of car.	*Section 5.7.4* End handholds shall be oriented horizontally, one near each side on each end projecting from the face of the end sill or sheathing. The clearance point of the outboard end of the end handhold shall be not more than 16 inches (406 mm) from side of car.	Part 231 requires that handholds be flush with or not project more than 1 inch beyond the face of the end sill. SS-M-016-06 requires end handholds to project from the face of the end sill or sheathing. APTA believes that this provides the best method to locate the end handholds on the car.	Deviation
49 CFR 231.14(d)(4)(i) Manner of application. (i) Handholds shall be flush with or project not more than 1 inch beyond face of end sill.	*Section 5.7.4* End handholds shall be oriented horizontally, one near each side on each end projecting from the face of the end sill or sheathing. The clearance point of the outboard end of the end handhold shall be not more than 16 inches (406 mm) from side of car.	Both Part 231.12(b)(4) and SS-M-016-06 require end handholds to be located horizontally, one near each side on each end projecting downward from face of vestibule end sill. Clearance of outer end of handhold shall be not more than 16 inches from side of car.	No change
49 CFR 231.14(d)(4)(ii) End handholds shall be securely fastened with bolts or rivets.	*Section 4.4* a) All safety appliances shall be securely fastened to the carbody structure.	Both Part 231.12(c)(4) and SS-M-016-06 require end handholds to be securely fastened to the carbody structure. Both documents also require that suitable steps and handholds shall be provided for employees to reach marker sockets or brackets.	No change
49 CFR 231.14(d)(4)(iii) When marker sockets or brackets are located so that they can not be conveniently reached from platforms, suitable steps and handholds shall be provided for men to reach such sockets or brackets.	*Section 5.11.1* When marker sockets or brackets are located so that they cannot be conveniently reached from platforms, suitable steps and handholds shall be provided for employees to reach such sockets or brackets. These steps and handholds shall follow the requirements for side door steps and side door handholds respectively. Alternately, the requirements for ladders may be used.	Both Part 231.12(c)(4) and SS-M-016-06 require end handholds to be securely fastened to the carbody structure. Both documents also require that suitable steps and handholds shall be provided for employees to reach marker sockets or brackets.	No change

Safety Appliance Standards
Comparison of APTA SS-M-016-06 to 49 CFR 231 & 238

Code of Federal Regulations	APTA SS-M-016-06	Justification	Status
49 CFR 231.14(e)(1) End handrails. (On cars with projecting end sills.) (1) Number. Four.	*Section 5.9.1* Open platform cars shall have the platform area enclosed with either a handrail or shortened walls. *Section 5.9.2* A handrail or a shortened wall is used on open platform cars to enclose the platform area and stabilize an employee standing on the open platform.	End platform handholds and handrails are specified in Part 231 for cars with open-end platforms and cars without end platforms. SS-M-016-06 does not include provisions for handrails on open platform cars. A specific number of handholds are not required but the standard does require that a handrail or shortened wall be used to enclose the platform and stabilize an employee standing on the open platform.	Deviation
49 CFR 231.14(e)(2) Dimensions. Minimum diameter, five-eighths of an inch, wrought iron or steel. Minimum clearance, 2, preferably 2-1/2, inches.	*Section 5.9.3* Handrails shall be no less than 1 inch (25.5 mm) diameter tubing with a minimum wall thickness of 1/16 inch (1.6 mm).	Part 231 requires a minimum clearance of 2, preferably 2-1/2, inches. SS-M-016-06 requires that handrails have no less than 1 inch (25.5 mm) diameter tubing with a minimum wall thickness of 1/16 inch (1.6 mm).	Deviation
49 CFR 231.14(e)(3) Location. One on each side of each end, extending horizontally from doorpost or vestibule frame to a point not more than 6 inches from corner of car, then approximately vertical to a point not more than 6 inches from top of platform end sill; horizontal portion shall be not less than 30 nor more than 60 inches above platform end sill.	*Section 5.9.4* a) Open platform cars shall have the platform area enclosed with either a handrail or shortened walls. The handrail may be continuous or may be intermittent to extend between other members of the car such as collision posts and corner posts. b) If an intermittent handrail is used, the end of the handrail shall be capped with a rounded end to reduce risk of injury. c) The distance from the end of the handrail to a vertical car member shall not exceed 4 inches (102 mm). d) The handrail shall be at least 42 inches (1071 mm)	SS-M-016-06 provides greater details on the location of handrails on open platforms.	Deviation

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	from the top of the platform floor to the top of the handrail, including entry doors. e) The handrail arrangement shall be designed such that a 5 inch (127.5 mm) diameter ball cannot pass through any space between handrail members or between the handrail and the carbody. f) Handrail members shall not be unsupported for spans over 48 inches (1224 mm). g) The railing and stile assembly may be welded but the ends of the final assembly must be securely fastened to the car structure. h) If a shortened wall is used, it shall meet the location requirement for handrails as detailed in items a) through g) above.		
49 CFR 231.14(e)(4) Manner of application. End handrails shall be securely fastened with bolts, rivets or screws.	*Section 4.4* a) All safety appliances shall be securely fastened to the carbody structure.	Both Part 231.12(b)(4) and SS-M-016-06 require handrails to be securely fastened to the carbody structure.	No change
49 CFR 231.14(f)(1) Side-door steps--(1) Number. One under each door.	*Section 5.3.1* At least one side door step per car side is required on cars that do not have a minimum of one passenger entrance per car side with the lowest step at a height of 24 inches (610 mm) above top of rail (ATR) or less.	Part 231 requires one step under each side door. SS-M-016-06 requires at least one side door step per car side on cars that do not have at least one passenger entrance per car side with the lowest step at a height of 24 inches ATR or less. This will enable employees to have access to at least one entrance on each side of a car with only high-level	Deviation

Code of Federal Regulations	APTA SS-M-016-06	Justification	Status
		entrances. This also omits the seemingly redundant requirement for a side door step to be placed at a low-level entrance that already allows access to the car with a step at a height of 24 inches ATR or less.	
49 CFR 231.14(f)(2) Dimensions. Minimum length of tread, 10, preferably 12, inches. Minimum cross-sectional area, 1/2 by 1-1/2 inches or equivalent, wrought iron or steel. Minimum clear depth, 8 inches.	*Section 5.3.3* a) The minimum useable length of tread shall be 12 inches (305 mm). b) Side door step treads shall be no less than 1/2 inch (13 mm) thick and no less than 2 inches (51 mm) wide. Alternate material sections may be used if they maintain the equivalent strength and rigidity of a 1/2 inch (13 mm) thick by 2 inch (51 mm) width step. Tread width shall be maintained at a 2 inch (51 mm) minimum. c) Steps exceeding 18 inches (457 mm) in depth shall have an additional tread and be transversely braced or equivalent. d) The clear depth above the entire useable length of the lowest side door step tread shall be no less than 8 inches (203 mm) and the clear depth above the entire useable length of all other side door step treads shall be 6 inches (152 mm). The clear width of all side door step treads shall be no less than 6 inches (152 mm) with the trucks rotated to simulate the maximum curvature specified for the uncoupled car.	SS-M-016-06 requires that the side door step have a minimum tread length of 12 inches, whereas Part 231 permits a 10 inch tread. Part 231 would permit steps thinner than 1/2 inch if the width is increased to provide the same cross sectional area as a 1/2 inch thick by 1-1/2 inch wide step. Such a step would be less stiff and provide less support than the nominal 1/2 inch by 1-1/2 inch step. In addition to requiring that the step be 1/2 inch thick regardless of its width, SS-M-016-06 also requires that it be no less than 2 inches wide, rather than 1-1/2 inches wide. This represents a noticeable increase in step stiffness and the wider step is also more comfortable to the foot when supporting a person's weight. Part 231 requires a minimum clear depth of 8 inches above the side door step. SS-M-016-06 requires that a minimum clear depth of 8 inches above the lowest step and a minimum clear depth of 6 inches above all other steps, based on an ergonomic analysis by APTA of the clear depth of the step.	Deviation

Code of Federal Regulations	APTA SS-M-016-06	Justification	Status
	e) To account for minor deviations, the application of side door steps shall be such that a box with the following dimensions can pass through the opening above the side door step to the point where the box is flush with the outer edge of the step. See Figure 3.		
49 CFR 231.14(f)(3) Location. Outside edge of tread of step not more than 2 inches inside of face of side of car. Tread not more than 24, preferably not more than 22, inches above the top of rail.	*Section 5.3.4* b) The design goal is to have the tread of the side door step as close to the top of rail as the clearance diagram permits. The lowest tread shall be not more than 24 inches (610 mm), preferably not more than 22 inches (560 mm), above the top of rail. c) The design goal is to have the outside edge of the tread of the side door step as close to being flush with the side of the car as the clearance diagram permits. To align side door step width with respect to handholds, in the transverse direction, the outside edge of any step tread shall not be more than 6 inches (152 mm) inboard or outboard of the inside surface of the lowest adjacent side handhold. In addition, the outside edge of any step tread shall be no more than 2 inches (51 mm) inboard of any car structure below the lowest adjacent side handhold in the area from the inboard clearance point of the handhold to the outboard vertical leg of the step. If the clearance diagram of the railroad does not allow this 2 inch requirement to be achieved, up to 4 inches (102 mm)	Both Part 231 and SS-M-016-06 require the outside edge of tread of step shall be not more than 2 inches inside of face of side of car. SS-M-016-06 further clarifies that the outside edge of any sill step tread be no more than 2 inches inboard of any car structure below the lowest adjacent side handhold. If the clearance diagram of the railroad does not allow this 2 inch requirement to be achieved, up to 4 inches (102 mm) may be allowed provided the lowest tread is no more than 21 inches above the top of rail. This defines the sill step tread in relation to both its corresponding handhold and the car structure. Both Part 231 and SS-M-016-06 require the lowest tread to be not more than 24 inches, preferably not more than 22 inches, ATR.	No change

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	may be allowed provided the lowest tread is no more than 21 inches above the top of rail. See Figure 7.		
49 CFR 231.14(f)(4)(i) Manner of application. (i) Steps exceeding 18 inches in depth shall have an additional tread and be laterally braced.	*Section 5.3.3* c) Steps exceeding 18 inches (457 mm) in depth shall have an additional tread and be transversely braced or equivalent.	Both Part 231 and SS-M-016-06 require steps exceeding 18 inches in depth to have an additional tread and be transversely braced.	No change
49 CFR 231.14(f)(4)(ii) Side-door steps shall be securely fastened with not less than 1/2-inch bolts with nuts outside (when possible) and riveted over, or with not less than 1/2-inch rivets.	*Section 4.4* a) All safety appliances shall be securely fastened to the carbody structure.	Both Part 231 and SS-M-016-06 require side door steps to be securely fastened to the carbody structure. Both documents also require that suitable steps and handholds shall be provided for employees to reach marker sockets or brackets.	No change
49 CFR 231.14(f)(4)(iii) A vertical handhold not less than 24 inches in clear length shall be applied above each side-door step on door post.	*Section 5.5.3* Handholds shall be no less than 5/8 inch (16 mm) diameter. Minimum clear length of vertical handholds shall be 24 inches (610 mm). Minimum clearance shall be 2 inches (51 mm), preferably 2.5 inches (64 mm). *Section 5.5.4* a) There shall be one vertical side door handhold over each side door step. b) The lowest clearance point of the side door handhold shall be at most 54 inches (1372 mm) ATR. c) If the side door handhold is located outside of the side door opening, the side door handhold shall be	Part 231 requires a 24" vertical handhold to be applied over each side door step. SS-M-016-06 requires this and further specifies the location of the handhold to provide an ergonomic means for the 5th percentile female and 95th percentile male to use the handhold.	Improvement

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	located no more than 6 inches (152 mm) from the vertical inside face of the door opening. d) On cab cars with non-passenger side entrances, vertical side door handholds shall be installed to continue to a point at least 58 inches (1473 mm) above the cab floor at the door entrance. If the length of the handhold exceeds 60 inches (1524 mm), it shall be securely fastened with two fasteners at each end.		
49 CFR 231.14(g)(1) Uncoupling levers. (1) Uncoupling attachments shall be applied so they can be operated by a person standing on the ground.	*Section 5.10.1* Except as provided in Section 6, each car shall have either a mechanical uncoupling device at each end of the car or an uncoupling mechanism operated by controls located in a secure location in the car. b) Uncoupling attachments shall be applied so they can be operated by a person standing on the ground.	Part 231.12(d)(1) requires uncoupling attachments to be applied so they can be operated by a person standing on the ground. SS-M-016-06 requires either a mechanical uncoupling device at each end of the car for a mechanical coupler or an uncoupling mechanism operated by controls located in a secure location in the car for an electric coupler. SS-M-016-06 also requires uncoupling attachments to be applied so they can be operated by a person standing on the ground.	Improvement
49 CFR 231.14(g)(2) Minimum length of ground uncoupling attachment, 42 inches, measured from center line of end of car to handle of attachment.	*Section 5.10.3* If the uncoupling device is mechanically operated from the side of the car, the following shall apply: a) Under all operating conditions, the outside surface of the uncoupling device handles shall be no more than	The dimensioning system used in SS-M-016-06 better defines the relationship between the uncoupling device and the distance to the side of the car from which a person would be operating the device. It is also easier to measure and determine compliance on some cars.	Improvement

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	14 inches (356 mm) closer to the car center than the inside surface of the adjacent side handhold. See Figure 15. b) Uncoupling attachments shall be applied so they can be operated by a person standing on the ground. c) The bottom end of the handle shall be no less than 12 inches (305 mm) and no more than 15 inches (381 mm) below the centerline of the outermost pivot point of the uncoupling lever to which the handle is attached. d) The end of handle shall be constructed to provide a minimum 2 inches (51 mm) clearance around the handle.		
49 CFR 231.14(g)(3) On passenger-train cars used in freight or mixed-train service, the uncoupling attachment shall be so applied that the coupler can be operated from the left side of car.	*Section 5.10.4* When used, the uncoupling levers shall be so applied that the coupler can be operated from the left side of the car as seen when facing the end of the car from the ground.	Both Part 231.12(d)(3) and SS-M-016-06 require the uncoupling attachment to be so applied that the coupler can be operated from left side of car.	No change
49 CFR 231.18 Cars of construction not covered specifically in the foregoing sections in this part, relative to handholds, sill steps, ladders, hand brakes and running boards may be considered as of special construction, but shall have, as nearly as possible, the same complement of handholds, sill steps, ladders, hand brakes, and running	N/A	APTA SS-M-016-06 defines safety appliances by function rather than by location or by car configuration. 49 CFR 231 contains three different passenger car types in parts 231.12 (wide vestibules), 231.13 (open-end platforms) and 231.14 (without end platforms). Modern equipment designs do not follow these specific car	Improvement

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boards as are required for cars of the nearest approximate type.		configurations. The passenger railroads have introduced multiple level cars, cars with center boarding, cab cars, etc. The APTA standard was developed to provide clarity in the design, fabrication and installation of safety appliances on modern designs of passenger cars. The standard clearly defines the function of each type of safety appliance and gives detailed requirements on the dimensions, material, location and manner of attachment.	
49 CFR 231.19 Right or Left refers to side of person when facing end or side of car from ground.	*Section 5.10.4* When used, the uncoupling levers shall be so applied that the coupler can be operated from the left side of the car as seen when facing the end of the car from the ground.	The only location where the terms "right" or "left" are used in SS-M-016-06 is in the uncoupling device section. In this section, it is specified that the left side of the car is as seen when facing the end of the car from the ground.	No change
49 CFR 231.20 To provide for the usual inaccuracies of manufacturing and for wear, where sizes of metal are specified, a total variation of 5 percent below size given is permitted.	*Section 4.3* To allow for standard mill tolerances, actual sizes of components (i.e. material thickness, diameter, etc.) may be 5% below the nominal sizes. Clearance dimensions are minimum dimensions (-0%).	Both Part 231 and SS-M-016-06 allow a variation of 5% in component size.	No change
49 CFR 238.230(a) Applicability. This section applies to passenger equipment placed in service on or after January 1, 2007.	*Section 1.1* This standard applies to new railroad passenger cars of all types, including baggage cars, with initial procurement contract awarded on or after January 1, 2008, for use on the general railroad system of the United States and Canada. This standard does not apply to non-passenger carrying locomotives.	Part 231 and SS-M-016-06 have different applicability dates. This has no impact to either standard.	No change
49 CFR 238.230(b) Welded Safety Appliances. Except as provided in this	*Section 4.4 a)* All safety appliances shall be securely fastened to the	Both Part 231 and SS-M-016-06 require safety appliances to be securely fastened to the carbody	No change

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section, all passenger equipment placed into service on or after January 1, 2007, that is equipped with a safety appliance, required by the ``manner of application" provisions in part 231 of this chapter to be attached by a mechanical fastener (i.e., bolts, rivets, or screws), shall have the safety appliance and any bracket or support necessary to attach the safety appliance to the piece of equipment mechanically fastened to the piece of equipment.	carbody structure.	structure.	
49 CFR 238.230(b)(1) Safety appliance brackets or supports considered part of the car body. Safety appliance brackets or supports will be considered part of the car body and will not be required to be mechanically fastened to the piece of passenger equipment if all of the following are met:	*Section 4.4 b)* Brackets or supports to which safety appliances are fastened are considered part of the carbody and are not required to be mechanically fastened to the piece of passenger equipment if all of the following are met:	Both Part 231 and SS-M-016-06 have provisions for allowing safety appliance brackets or supports to be considered part of the carbody.	No change
49 CFR 238.230(b)(1)(i) The bracket or support is welded to a surface of the equipment's body that is at a minimum 3/16-inch sheet steel or structurally reinforced to provide the equivalent strength and rigidity of 3/16-inch sheet steel;	*Section 4.4 b) 4)* The bracket or support is welded to a surface of the carbody that is at a minimum 3/16 inch (5 mm) sheet steel or is structurally reinforced to provide the equivalent strength and rigidity of 3/16 inch (5 mm) sheet steel;	Both Part 231 and SS-M-016-06 have provisions for allowing safety appliance brackets or supports to be considered part of the carbody.	No change
49 CFR 238.230(b)(1)(ii) The area of the weld is sufficient to ensure a minimum weld strength, based on yield, of three times the strength of the number of SAE grade 2, 1/2 inch diameter bolts that would be required for each attachment;	*Section 4.4 b) 2)* The area of the weld is sufficient to ensure a minimum weld strength, based on yield, of three times the strength of the number of SAE Grade 2, 1/2 inch diameter (M12 Class 5.8) bolts that would be required for each attachment;	Both Part 231 and SS-M-016-06 have provisions for allowing safety appliance brackets or supports to be considered part of the carbody.	No change
49 CFR 238.230(b)(1)(iii) Except for any access required for attachment of the	*Section 4.4 b) 1)* Except for any access required for attachment of the	Both Part 231 and SS-M-016-06 have provisions for allowing safety appliance brackets or supports to be	No change

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safety appliance, the weld is continuous around the perimeter of the surface of the bracket or support;	safety appliance, the weld is continuous around the perimeter of the surface of the bracket or support;	considered part of the carbody.	
49 CFR 238.230(b)(1)(iv) The attachment is made with fillet welds at least 3/16-inch in size;	*Section 4.4 b) 3)* The attachment is made with fillet welds at least 3/16 inch (5 mm) in size;	Both Part 231 and SS-M-016-06 have provisions for allowing safety appliance brackets or supports to be considered part of the carbody.	No change
49 CFR 238.230(b)(1)(v) The weld is designed for infinite fatigue life in the application that it will be placed;	*Section 4.4 b) 6)* The weld is designed for infinite fatigue life in the application that it will be placed;	Both Part 231 and SS-M-016-06 have provisions for allowing safety appliance brackets or supports to be considered part of the carbody.	No change
49 CFR 238.230(b)(1)(vi) The weld is performed in accordance with the welding process and the quality control procedures contained in the current American Welding Society (AWS) Standard, the Canadian Welding Bureau (CWB) Standard, or an equivalent nationally or internationally recognized welding standard;	*Section 4.4 b) 7)* The weld is performed in accordance with the welding process and the quality control procedures contained in the current American Welding Society (AWS) Standard, the Canadian Welding Bureau (CWB) Standard or an equivalent nationally or internationally recognized welding standard;	Both Part 231 and SS-M-016-06 have provisions for allowing safety appliance brackets or supports to be considered part of the carbody.	No change
49 CFR 238.230(b)(1)(vii) The weld is performed by an individual possessing the qualifications to be certified under the current AWS Standard, CWB Standard, or any equivalent nationally or internationally recognized welding qualification standard;	*Section 4.4 b) 8)* The weld is performed by an individual possessing the qualifications to be certified under the current AWS Standard, CWB Standard or any equivalent nationally or internationally recognized welding qualification standard;	Both Part 231 and SS-M-016-06 have provisions for allowing safety appliance brackets or supports to be considered part of the carbody.	No change
49 CFR 238.230(b)(1)(viii) The weld is inspected by an individual qualified to determine that all of the conditions identified in paragraph (b)(1)(i) through (b)(1)(vii) of this section are met prior to the equipment being placed in service; and	*Section 4.4 b) 9)* The weld is inspected by an individual qualified to determine that all welds are in conformance with the design drawings and the current AWS Standard, CWB Standard or any equivalent nationally or internationally recognized welding qualification standard; and,	Both Part 231 and SS-M-016-06 have provisions for allowing safety appliance brackets or supports to be considered part of the carbody.	No change
49 CFR 238.230(b)(1)(ix)	*Section 4.4 b) 10)*	Both Part 231 and SS-M-016-06 have provisions for	No change

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A written or electronic record of the inspection required in paragraph (b)(1)(viii) of this section shall be retained by the railroad operating the equipment and shall be provided to FRA upon request. At a minimum, this record shall include the date, time, location, identification of the person performing the inspection, and the qualifications of the person performing the inspection.	A written or electronic record of the inspection required in paragraph 9) of this section shall be preserved and shall be provided to the FRA or Transport Canada upon request. At a minimum, this record shall include date, time, location, identification of the person performing the inspection and the qualifications of the person performing the inspection.	allowing safety appliance brackets or supports to be considered part of the carbody.	
49 CFR 238.230(b)(2) Directly welded safety appliances. Passenger equipment that is equipped with a safety appliance that is directly attached to the equipment by welding (i.e., no mechanical fastening of any kind) may be placed in service only if the railroad meets the following:	N/A	N/A	N/A
49 CFR 238.230(b)(2)(i) The railroad submits a written list to FRA that identifies each piece of new passenger equipment equipped with a welded safety appliance as described in paragraph (b)(2) of this section and provides a description of the specific safety appliance;	N/A	N/A	N/A
49 CFR 238.230(b)(2)(ii) The railroad provides a detailed basis as to why the design of the vehicle or placement of the safety appliance requires that the safety appliance be directly welded to the equipment; and	N/A	N/A	N/A
49 CFR 238.230(b)(2)(iii) The involved safety appliance(s) on such equipment are inspected and handled pursuant to the requirements contained in Sec. 238.229(g) through (k).	N/A	N/A	N/A

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49 CFR 238.230(b)(3) Other welded safety appliances and safety appliance brackets and supports. Except for safety appliance brackets and supports identified in paragraph (b)(1) of this section, safety appliance brackets and supports on passenger equipment shall not be welded to the car body unless the design of the equipment makes it impractical to mechanically fasten the safety appliance and it is impossible to meet the conditions for considering the bracket or support part of the car body contained in paragraph (b)(1) of this section. Prior to placing a piece of passenger equipment in service with a welded safety appliance bracket or support as described in this paragraph, the railroad shall submit documentation to FRA, for FRA's review and approval, containing all of the following information: (i) Identification of the equipment by number, type, series, operating railroad, and other pertinent data; (ii) Identification of the safety appliance bracket(s) or support(s) not mechanically fastened to the equipment and not considered part of the car body under paragraph (b)(1) of this section; (iii) A detailed analysis describing the necessity to attach the safety appliance bracket or support to the equipment by a means other than mechanical fastening; (iv) A detailed analysis describing the inability to make the bracket or support part of the car body as provided for in paragraph (b)(1) of this section; and (v) A copy and description of the consensus or other	N/A	N/A	N/A

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appropriate industry standard used to ensure the effectiveness and strength of the attachment;			
49 CFR 238.230(c) Inspection and repair. Passenger equipment with a welded safety appliance or a welded safety appliance bracket or support will be considered defective and shall be handled in accordance with Sec. 238.17(e) if any part or portion of the weld is defective as defined in Sec. 238.229(d). When appropriate, civil penalties for improperly using or hauling a piece of equipment with a defective welded safety appliance or safety appliance bracket or support addressed in this section will be assessed pursuant to the penalty schedule contained in Appendix A to part 231 of this chapter under the appropriate defect code contained therein.	N/A	N/A	N/A
49 CFR 238.230(c)(1) Any safety appliance bracket or support approved by FRA pursuant to paragraph (b)(3) of this section shall be inspected and handled in accordance with the requirements contained in Sec. 238.229(g) through (k).	N/A	N/A	N/A
49 CFR 238.230(c)(2) Any repair to a safety appliance bracket or support considered to be part of the car body under paragraph (b)(1) of this section shall be conducted in accordance with APTA Standard SS-C&S-020-03--Standard for Passenger Rail Vehicle Structural Repair (September 2003), or an alternative procedure approved by FRA pursuant to Sec. 238.21, and shall ensure that the repair meets the requirements contained in paragraphs	*Section 8.3* When damaged safety appliances and/or their brackets or supporting structure are repaired or replaced, they shall be restored to their original design. See also APTA SS-C&S-020-03, Standard for Passenger Rail Vehicle Structural Repair. Fastener locking devices shall not be reused.	Both Part 231 and SS-M-016-06 require that when safety appliances and/or their brackets or supporting structure are repaired or replaced, they must be restored to their original design.	No change

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(b)(1)(i) through (b)(1)(vii) of this section. The Director of the Federal Register approves incorporation by reference of the APTA Standard SS-C&S-020-03 (September 2003), ``Standard for Passenger Rail Vehicle Structural Repair," in this section in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. You may obtain a copy of the incorporated standard from the American Public Transportation Association, 1666 K Street, Washington, DC 20006. You may inspect a copy of the incorporated standard at the Federal Railroad Administration, Docket Clerk, 1120 Vermont Ave., NW., Suite 7000, Washington, DC 20590 or at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202-741-6030, or go to http://wwww.archives.gov/federal_register/code_of_federal_**regulations**/ibr_locations.html			
49 CFR 238.230(d) Passenger Cars of Special Construction. A railroad or a railroad's recognized representative may submit a request for special approval of alternative compliance pursuant to Sec. 238.21 relating to the safety appliance arrangements on any passenger car considered a car of special construction under Sec. 231.18 of this chapter. Any such petition shall be in the form of an industry-wide standard and at a minimum shall:	N/A	N/A	N/A
49 CFR 238.230(d)(1) Identify the type(s) of car to which the standard would	N/A	N/A	N/A

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be applicable;			
49 CFR 238.230(d)(2) As nearly as possible, based upon the design of the equipment, ensure that the standard provides for the same complement of handholds, sill steps, ladders, hand or parking brakes, running boards, and other safety appliances as are required for a piece of equipment of the nearest approximate type already identified in part 231 of this chapter;	N/A	N/A	N/A
49 CFR 238.230(d)(3) Comply with all statutory requirements relating to safety appliances contained at 49 U.S.C. 20301 and 20302;	N/A	N/A	N/A
49 CFR 238.230(d)(4) Specifically address the number, dimension, location, and manner of application of each safety appliance contained in the standard;	N/A	N/A	N/A
49 CFR 238.230(d)(5) Provide specific analysis regarding why and how the standard was developed and specifically discuss the need or benefit of the safety appliance arrangement contained in the standard;	N/A	N/A	N/A
49 CFR 238.230(d)(6) Include drawings, sketches, or other visual aids that provide detailed information relating to the design, location, placement, and attachment of the safety appliances; and	N/A	N/A	N/A

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49 CFR 238.230(d)(7) Demonstrate the ergonomic suitability of the proposed arrangements in normal use.	N/A	N/A	N/A
49 CFR 238.230(e) Any industry standard approved pursuant to Sec. 238.21 will be enforced against any person who violates any provision of the approved standard or causes the violation of any such provision. Civil penalties will be assessed under part 231 of this chapter by using the applicable defect code contained in Appendix A to part 231 of this chapter.	N/A	N/A	N/A
N/A CFR Part 231 does not address this issue.	Section *4.3* All sill steps, side door steps, ladders and handholds shall be made of steel with minimum yield strength of 25,000 psi (170 MPa). Stainless steel of equivalent strength may be used. Safety appliances may be cast, rolled, forged or made by any other process that provides the required strength.		Improvement
N/A CFR Part 231 does not address this issue.	*Section 5.1.3.3* a) The wheel type handbrake shall have a minimum 4 inch (102 mm) hand clearance. b) The wheel diameter shall be at least 22 inches (559 mm).		Improvement
N/A CFR Part 231 does not address this issue.	*Section 5.1.3.4* The parking brake manual release lever shall have a minimum 2 inch (51 mm) hand clearance.		Improvement

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N/A CFR Part 231 does not address this issue.	*Section 5.1.4* The handbrake housing must be securely fastened. Bolts used for mounting the handbrake shall be designed to resist the maximum chain force with a minimum factor of safety of 2. The maximum chain force is that developed by the handbrake mechanism when a 74 lb. (34 kg) force is applied 3 inches (76 mm) in from the end of the application lever, typically 20 to 24 inches (508 to 610 mm) long, or on the rim of a handbrake wheel unless the design of the mechanism restricts the applied force to a lower value. Hand brake mounting brackets are to be securely fastened unless the use of mechanical fasteners is not feasible for the particular application. Bell crank mounting brackets, sheave wheel mounting brackets, brake rod supports and guides, and chain supports and guides are not considered safety appliances, and hence are not subject to the manner of application requirements in this standard. See Figures 5 and 6 for typical handbrake applications.		Improvement
N/A CFR Part 231 does not address this issue.	*Section 5.3.4* a) For side door steps that extend beyond the side door opening in the longitudinal direction, the inside face of the leg of the side door step that is located under the door opening shall be at least 10 inches (254 mm) in the longitudinal direction from the vertical inside face of the door opening. The inside face of the opposite leg of the side door step shall be located on		Improvement

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	the centerline of the side door handhold or extend beyond it.		
N/A CFR Part 231 does not address this issue.	*Section 5.4.1* Except as provided in Section 6, sill step handholds shall be applied over each sill step.		Improvement
N/A CFR Part 231 does not address this issue.	*Section 5.6.1* Except as provided in Section 6, a side door handhold shall be applied over each side door step.		Improvement
N/A CFR Part 231 does not address this issue.	*Section 5.8.1* Two collision post handholds shall be at each end passageway.		Improvement
N/A CFR Part 231 does not address this issue.	*Section 5.8.3* Handholds shall be no less than 5/8 inch (16 mm) diameter. Minimum clearance shall be 2 inches (51 mm), preferably 2.5 inches (64 mm).		Improvement
N/A CFR Part 231 does not address this issue.	*Section 5.8.4* Collision post handholds shall be oriented vertically. The lowest clearance point shall be at most 44 inches (1118 mm) above the floor of the walkway and the highest clearance point shall be at least 60 inches (1524 mm) above the floor of the walkway.		Improvement
N/A CFR Part 231 does not address this issue.	*Section 5.11.2.1* Ladders are not required and are elective safety appliances. Ladders enable an employee to access equipment or to perform a function that cannot be done from the ground.		Improvement
N/A CFR Part 231 does not address this issue.	*Section 5.11.2.2* a) The minimum useable length of tread shall be not		Improvement

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	less than 16 inches (406 mm) on side ladders and not less than 14 inches (356 mm) on end ladders. b) Treads of rectangular cross-section shall be no less than 1/2 inch (13 mm) thick and no less than 2 inches (51 mm) wide. The minimum diameter of treads of circular cross-section shall be 5/8 inch (16 mm). c) Minimum clearance of treads shall be 2 inches (51 mm), preferably 2.5 inches (64 mm). d) All ladder treads shall have foot guards. Ladder side rails may serve as foot guards (Figure 19).		
N/A CFR Part 231 does not address this issue.	*Section 5.11.2.3* a) If the ladder is used for access to the roof, the top ladder tread shall be no less than 12 inches (305 mm), nor more than 18 inches (457 mm), below the mounting surface of the outboard end of the adjacent roof handhold. b) The maximum spacing between ladder treads shall be 19 inches (483 mm). Spacing of ladder treads shall be uniform within a limit of 2 inches (51 mm) from top ladder tread to bottom tread of ladder.		Improvement

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N/A CFR Part 231 does not address this issue.	*Section 5.11.3.1* Roof handholds are not required and are elective safety appliances. Roof handholds are used on the roof of the car to stabilize an employee when performing such tasks as inspecting equipment located on the roof.		Improvement
N/A CFR Part 231 does not address this issue.	*Section 5.11.3.2* Handholds shall be no less than 5/8 inch (16 mm) diameter. Minimum clear length shall be 16 inches (406 mm). Minimum clearance shall be 2 inches (51 mm), preferably 2.5 inches (64 mm).		Improvement
N/A CFR Part 231 does not address this issue.	*Section 5.11.3.3* If roof handholds are located above a ladder, in the transverse direction, the clearance points of the inboard end of roof handholds (bulkhead top handholds) shall be no more than 8 inches (203 mm) inboard from and no further outboard than the clearance point of the inboard end of the top ladder tread.		Improvement
N/A CFR Part 231 does not address this issue.	*Section 6* Semi-permanently coupled cars need not be equipped with uncoupling levers, sill steps or end or side handholds at the articulated or drawbar connections between adjacent carbodies. However, when elective safety appliances are applied at such locations, they shall comply with the requirements of paragraph 5.11 of this standard. Semi-permanently coupled cars shall be equipped with		Improvement

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	sufficient handbrakes/parking brakes to meet the grade holding capacity defined in APTA SS-M-006-98, Rev. 1.		
N/A CFR Part 231 does not address this issue.	*Section 7* The railroad and the carbuilder shall use the checklist in Annex A to verify that all the requirements of this standard have been addressed. The railroad shall request a safety appliance sample car inspection from the FRA in the United States or Transport Canada in Canada on each new design of car. If any design changes take place to safety appliances during production, the carbuilder or railroad shall request an additional safety appliance sample car inspection. Previous sample car inspections can be applied to new orders of the same design if there are no changes to the safety appliances. However, FRA and Transport Canada will require submittal of the safety appliance arrangement drawings for that order with reference to the previous sample car inspection. This inspection can be combined with the standard sample car inspection. Both FRA and Transport Canada require inspection of items in addition to safety appliances during the sample car inspection. Contact FRA and/or Transport Canada for details on		Improvement

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	these requirements. It is recommended that a safety appliance design review with the FRA or Transport Canada be conducted as early as possible in the design process. The carbuilder or railroad shall submit a written request to FRA and/or Transport Canada at least 30 days prior to a sample car inspection. The letter shall include the drawings of all safety appliances and may include the completed checklist in Annex A.		
N/A CFR Part 231 does not address this issue.	*Section 8.1* Safety appliances shall be inspected in accordance with 49 CFR 238.303, APTA SS-I&M-007-98, Rev. 1, and Transport Canada's Railway Passenger Car Inspection and Safety Rules. Safety appliances shall be part of the periodic inspection of the car in accordance with 49 CFR 238.307, APTA SS-I&M-007-98, Rev. 1, and Transport Canada's Railway Passenger Car Inspection and Safety Rules.		Improvement
N/A CFR Part 231 does not address this issue.	*Section 8.2* Any safety appliance defects uncovered in the inspections required in Section 9.1 shall be repaired in accordance with 49 CFR 238.303, 49 CFR 238.307, APTA SS-I&M-007-98, Rev. 1, and Transport Canada's Railway Passenger Car Inspection and Safety Rules.		Improvement

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N/A CFR Part 231 does not address this issue.	*Section 8.3* When damaged safety appliances and/or their brackets or supporting structure are repaired or replaced, they shall be restored to their original design. See also APTA SS-C&S-020-03, Standard for Passenger Rail Vehicle Structural Repair. Fastener locking devices shall not be reused.		Improvement

APTA STANDARDS DEVELOPMENT PROGRAM

STANDARD

American Public Transportation Association
1300 I Street, NW, Suite 1200 East, Washington, DC 20005

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Passenger Rail Equipment Safety Standards (PRESS) Construction & Structural Working Group

Attachment Strength of Interior Fittings for Passenger Railroad Equipment

Abstract: This standard contains minimum requirements for the static strength of interior fittings and the strength of attachment of interior fittings to the carbody structure.

Keywords: attachment, design, fittings, strength, load

Summary: This standard provides requirements for the minimum strength and attachment strength of interior fittings on passenger railroad equipment, along with design practices required to ensure the proper functioning of interior fittings and to reduce the extent and severity of passenger injuries resulting from secondary impact during a collision, derailment or other emergency.

Scope and purpose: This standard covers fittings used in the interior of commuter and intercity passenger rail cars, as well as operating cabs of passenger equipment. It specifies the minimum strength and attachment strength for interior fittings, including overhead luggage storage racks, luggage stacks, stanchions and handholds, windscreens and partitions, bicycle racks, and miscellaneous interior fittings. It also contains design requirements for interior fittings. For passenger seating, reference APTA-PR-CS-S-016-99, Latest revision; for major equipment attachments, reference APTA-PR-CS-S-034-99, Latest revision; and for safety appliances, reference APTA-PR-M-S-016-06, Latest revision. This standard shall be used in specifications for the procurement of new passenger railcars excluding options to an existing contract. It shall also be used, as applicable, in specifications for rebuilding existing rail passenger vehicles, where carbody structure makes this practical, and for replacement systems.

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Introduction

This introduction is not part of APTA PR-CS-S-006-98, Rev. 2.1, "Attachment Strength of Interior Fittings for Passenger Railroad Equipment."

This standard provides a consistent set of requirements for interior fittings on all types of passenger intercity or commuter railroad equipment. The requirements in this standard are intended to prevent failure or separation of interior fittings from the carbody during a collision, derailment or other incident, and to provide a crashworthy vehicle interior that will significantly reduce the extent and severity of passenger injuries due to secondary impact occurring during an incident.

This standard establishes safety requirements for six subsystems within the interior of a passenger rail vehicle: overhead luggage storage racks, luggage stacks, stanchions/handholds, windscreens/partitions, bicycle racks, and miscellaneous interior fittings.

This standard applies to all:

- Railroads that operate intercity or commuter passenger train service on the general railroad system of transportation; and
- Railroads that provide commuter or other short-haul rail passenger train service in a metropolitan or suburban area, including public authorities operating passenger train service.

Attachment Strength of Interior Fittings for Passenger Railroad Equipment

1. Overview

1.1 General

The following requirements define the required strength for permanently or semi-permanently attached interior fittings located within the passenger compartment, including the lavatory and operating cabs. Except where specifically stated, transient objects that passengers and crew members bring onto and remove from the equipment are not subject to the requirements herein.

To the extent possible, all interior fittings in a passenger car shall be recessed or flush-mounted. Sharp edges and corners shall be either avoided or padded to mitigate the consequences of an impact with such surfaces. Where protrusions are unavoidable, rounded edges shall be used.

Materials that may fracture to reveal sharp edges or dangerous inserts shall not be used. Wherever possible, use shall be made of energy-absorbing features in areas where passenger impact may occur.

At the time of publication, compliance with Revision 1 of this standard is required by regulation in *49 CFR Appendix G to Part 238—Alternative Requirements for Evaluating the Crashworthiness and Occupant Protection Performance of a Tier I Passenger Trainset*, and *49 CFR Part 238.733 for Interior fixture attachment.* Portions of this standard are intended to provide details on how to demonstrate compliance with the requirements of *49 CFR Part 238.233 for interior fittings attachment strength,* which apply to every tier. Tier III trainsets can comply with the interior fixture attachment strength requirements under *49 CFR 238.733 (a)(2)* only if the associated conditions are met. All the other dimensional (clearance, etc.), geometric requirements (lip, etc.) shall apply to Tier III trainsets too.

1.2 Compliance

Analysis shall be performed to demonstrate compliance with all requirements contained in this standard. The carbuilder is responsible for demonstrating compliance with the requirements of this standard.

2. Strength requirements

2.1 Overhead luggage storage racks

2.1.1 On equipment ordered before December 1, 2021

All longitudinal overhead luggage storage racks shall be designed to provide longitudinal and lateral restraint for stowed articles. Overhead luggage racks shall be open shelf–type, open ladder–type or fully enclosed modular units.

Overhead storage racks, including their attachments to the carbody, shall have ultimate strength sufficient to resist loads due to individually applied static loads represented by the following values, acting on the mass of the luggage stowed. The mass of the luggage stowed may be determined by the railroad.

- Longitudinal: 8g
- Vertical: 4g
- Lateral: 4g

Overhead storage racks shall have sufficient strength to support a distributed load as defined by the operating railroad, but not less than 250 lb (1111 N) applied midway between adjacent supports without permanent deformation. Overhead storage rack door latches shall be designed to withstand a 120 lb (536 N) distributed load, acting perpendicular to the door latch face, without releasing.

2.1.2 For equipment ordered on or after December 1, 2021

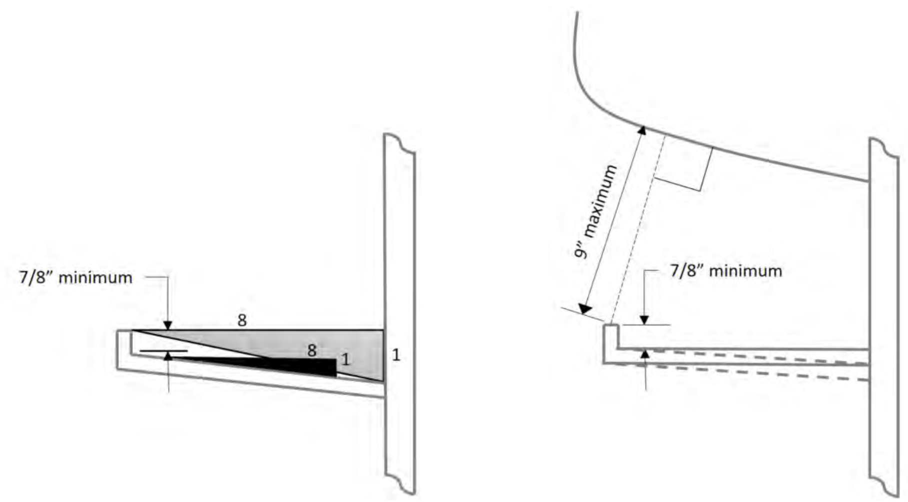
All longitudinal overhead luggage storage racks shall be designed to provide longitudinal and lateral restraint for stowed articles. To restrain the lateral movement of luggage, these racks shall have:

- a minimum ⅞ in. (2.22 cm) high lip on the longitudinal front rail, and rear rail on open type racks; and
- a slope downward in the outboard direction at a minimum ratio of 1:8 with respect to a horizontal plane. The lip on the edge of the luggage rack may be used to achieve the minimum slope.

For luggage racks with less than 9 in. of vertical clearance, a minimum ⅞ in. (2.22 cm) lip may be used in lieu of the 1:8 slope, reference **Figure 1** for examples of compliant designs.

To restrain the longitudinal movement of luggage, transverse vertical dividers shall be provided at no greater than 10 ft (3.05 m) intervals.

FIGURE 1
Schematic of Overhead Luggage Storage Rack Configurations



(a)
⅞ in. minimum lip required, measured from working surface of rack to tip of lip, *and* 1:8 slope required. Lip may be used to satisfy requirement.

(b)
For space-constrained installations where the perpendicular distance from ceiling to tip of lip is ≤ 9 in., rack slope requirement does not apply.

Overhead storage racks, including their attachments to the carbody, shall have ultimate strength sufficient to resist loads due to the following individually applied design static load factors acting on the mass of the luggage stowed, combined with the mass of the storage rack. The mass of the luggage stowed shall be determined by the railroad.

- Longitudinal: 8g
- Vertical: 4g
- Lateral: 4g

Overhead storage racks shall have sufficient strength to support a downward vertical load not less than 250 lb (1112 N) applied midway between adjacent supports on the inboard edge without permanent deformation of the luggage rack or its attachment to the carbody structure.

Latches for overhead storage rack door systems, when used, shall be designed to withstand a 120 lb (534 N) load, acting perpendicular to the latch toward the centerline of the car, without releasing. Luggage rack doors shall contain a positive securement device to secure the door in the closed position. The doors may be self-opening when the door latch is released.

2.2 Luggage stacks

All luggage stacks shall be designed to provide longitudinal and lateral restraint for stowed articles. Luggage stacks, including their attachments to the carbody, shall have ultimate strength sufficient to resist loads due to the following individually applied design static load factors acting on the mass of the luggage stowed, combined with the mass of the luggage stack. The minimum mass of luggage stowed shall be based on a distributed mass of 20 lb/sq. ft (100 kg/m^2) applied on each luggage-storage surface.

- Longitudinal: 8g
- Vertical: 4g
- Lateral: 4g

2.3 Handholds and stanchions

Handholds and stanchions, including handholds attached to windscreens and partitions, and their attachments to the carbody structure shall have an ultimate strength capable of resisting a design static load factor of 8g acting on the mass of the stanchion in any horizontal direction.

Handholds, other than those mounted to passenger seats, and their attachments to the carbody structure shall resist a 500 lb (2224 N) load acting in any direction at the midpoint of the span, distributed over a length of no more than 3 in., without local buckling or failure of the attachment. The handhold shall not permanently deform more than 2 percent of its length, measured at the midpoint of its span, after the load has been removed. Reference the APTA standard "Passenger Seats in Passenger Rail Cars," APTA-PR-CS-S-016-99, latest revision, for requirements pertaining to passenger seat handholds.

2.4 Windscreens and partitions

Windscreens and partition panels, and their attachments to the carbody, shall be capable of withstanding a 500 lb (2224 N) load applied normal to the panel in either direction at the midpoint, without failure of the panels or their attachment to the carbody.

2.5 Bicycle racks

Bicycle racks shall be designed to provide longitudinal, vertical and lateral restraint for stowed bicycles. Bicycle racks, including their attachments to the carbody, and the mechanism to secure bicycles to the racks, shall have ultimate strength sufficient to resist loads due to the following individually applied design static load factors acting on the mass of the bicycle(s) stowed, combined with the mass of the bicycle rack. The weight of a stowed bicycle shall be 50 lb (23 kg) for the purposes of this section.

- Longitudinal: 8g
- Vertical: 4g
- Lateral: 4g

2.6 Miscellaneous interior fittings

Miscellaneous interior fittings such as light fixtures and destination signs within a passenger compartment, including fittings located in the toilet/lavatory compartment, shall be attached to the carbody with sufficient ultimate strength to withstand applied loads as defined by the operating railroad, and individually applied static loads represented by the following design static load factors acting on the mass of the fitting:

- Longitudinal: 8g
- Vertical: 4g
- Lateral: 4g

Food service equipment such as, but not limited to, ovens, warmers, coffee makers, drink dispensers, blenders and toasters shall be attached to their mounting surfaces with sufficient ultimate strength to withstand individually applied static loads represented by the following design static load factors acting on the mass of the loaded equipment:

- Longitudinal: 8g
- Vertical: 4g
- Lateral: 4g

Strength of fixed workstation tables and their attachments to carbody structure is covered by the APTA standard “Fixed Workstation Tables in Passenger Rail Cars,” APTA-PR-CS-S 018-13, Latest revision.

Related APTA standards

APTA-PR-CS-S-011-99, “Cab Crew Seating Design and Performance”
APTA-PR-CS-S-016-99, “Passenger Seats in Passenger Rail Cars”
APTA-PR-CS-S-018-13, “Fixed Workstation Tables in Passenger Rail Cars”
APTA-PR-CS-S-034-99, “Design and Construction of Passenger Railroad Rolling Stock”
APTA-PR-M-S-016-06, “Safety Appliances for Rail Passenger Cars”

References

This standard shall be used in conjunction with the following publications. When the following standards are superseded by an approved revision, the revision shall apply.

49 CFR, Part 238, Passenger Equipment Safety Standards

Association of American Railroads:
AAR S-580, Locomotive Crashworthiness Requirements

Definitions

handhold: A bar or rail designed to be grasped with the hand. A handhold is secured by mechanical attachment to the wall or ceiling structure. Handholds may be oriented vertically, horizontally or at an angle.

interior fitting: Any auxiliary component in the passenger compartment or operating cab on passenger equipment that is mounted to the floor, ceiling, wall or end walls, and that projects into the passenger compartment or cab from the surface or surfaces to which it is mounted.

lateral: The horizontal direction perpendicular to the direction of travel of a rail vehicle.

longitudinal: A direction parallel to the normal direction of travel of a rail vehicle.

luggage rack: Any horizontally oriented receptacle used to store passenger luggage. Luggage racks are usually located over the passenger seating area and are secured to the carbody sidewall structure.

luggage stack: A series of vertically stacked receptacles used to store passenger luggage.

partition: A transverse or longitudinal panel that may enclose a room, or separate the passenger compartment from the operator’s area, luggage storage area, or food-service or equipment compartments.

passenger (railroad) equipment: All powered and unpowered passenger cars, locomotives used to haul a passenger car, and any other rail rolling equipment used in a train with one or more passenger cars.

stanchion: An upright handhold that extends from floor to ceiling and is mechanically attached to the floor, ceiling or wall.

windscreen: A panel located adjacent to side doorways that provides security and protection for the passengers from the elements.

Abbreviations and acronyms

AAR Association of American Railroads
CFR Code of Federal Regulations
FRA Federal Railroad Administration
N Newtons
NATSA North American Transportation Services Association

Summary of document changes

- Document formatted to the new APTA standard format.
- Sections have been moved and renumbered to accommodate the new format.
- Scope and summary moved to the front page.
- Definitions, abbreviations and acronyms moved to the rear of the document.
- Two new sections added: "Summary of document changes" and "Document history."
- Some global changes to section headings and numberings resulted when sections dealing with references and acronyms were moved to the end of the document, along with other cosmetic changes, such as capitalization, punctuation, spelling, grammar and general flow of text.
- Updated introduction section to reflect latest language and requirements addressed within this standard.
- Added Section 1.1 General under Overview to clarify certain requirements flowing down from the CFR. Also added provision to address hazards associated with materials that may break or fracture and become hazardous to interior occupants riding down a collision or derailment.
- Section 2.1 - Added in heading reference to dates associated with the new standard in order to "grandfather" existing equipment to previous standard only. Requirement of lip to retain luggage was added as a measure of protection based on the analysis conducted by Volpe National Transportation Surface Center (VNTSC).
- Section 2.1.2 - Added requirement to include mass of the storage rack in addition to the mass of the luggage stowed.
- Section 2.2 – a new section was added for Luggage stacks.
- Sections 2.3 and 2.4 – minor clarifications were made from the previous revision.
- Section 2.5 – a new section was created for Bicycle rack requirements for attachment strength. This section does not deal with placement of bicycle racks.
- Section 2.6 – clarifications were made to this section. Coat hooks were removed from the list of miscellaneous interior fittings.
- Revision 2.1: Clarified dates to requirements in sections 2.1.1 and 2.1.2.

Document history

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APTA STANDARDS DEVELOPMENT PROGRAM

STANDARD

American Public Transportation Association
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APTA PR-CS-S-034-99, Rev. 3.3

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Passenger Rail Equipment Safety Standards (PRESS) Construction and Structural Working Group

Design and Construction of Passenger Railroad Rolling Stock

Abstract: This standard contains structural and crashworthiness requirements for railroad passenger equipment of all types, including locomotive-hauled equipment, MU and cab cars, and non-passenger-carrying power cars and locomotives.

Keywords: analysis, collision post, corner post, strength, stress, structure test, severe deformation

Summary: This standard contains structural design requirements for passenger rail equipment. The standard is intended to consider the forces applied to the carbody and truck structures during collisions, derailments, and other emergencies.

Scope and purpose: This standard shall apply, unless otherwise indicated, to new railroad passenger equipment of all types, including locomotive-hauled, MU cars, and cab cars and non-passenger-carrying power cars and locomotives that are intended for use on the general railroad system of the United States. Passenger equipment designed with crash energy management features are no longer covered by this standard. The purpose of this document is to provide minimum structural standards and to improve the crashworthiness of passenger-carrying rail vehicles.

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List of Figures and Tables

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Introduction

This introduction is not part of APTA PR-CS-S-034-99, Rev. 3.3, "Design and Construction of Passenger Railroad Rolling Stock."

This standard is divided into five sections: "Materials," "Structural safety and crashworthiness requirements," "Design loads and practices," "Analysis," and "Tests". The "Materials" section provides basic requirements for the types of structural materials typically used in passenger railcars, as well as requirements for incorporating other materials into the railcar design. The "Design loads and practices" section provides structural requirements for ensuring a crashworthy carbody design. Separate requirements are provided for cab ends and non-cab ends of various types of passenger equipment, including cab cars, MU cars, coaches and non-passenger-carrying locomotives. Special considerations, such as articulated units, low-level boarding, and non-flat-end cabs, are addressed in these requirements. The minimum levels of analysis and testing required to demonstrate conformance with this standard are also provided. The "Analysis" and "Test" sections contain recommended practices for performing the elastic and plastic analyses and tests required by the "Design loads and practices" section. An informative Appendix A provides information on the history of the structural requirements in this standard.

This standard applies to all:

1. railroads that operate intercity or commuter passenger train service on the general railroad system of transportation; and
2. railroads that provide commuter or other short-haul rail passenger train service in a metropolitan or suburban area, including public authorities operating passenger train service.

This standard does not apply to:

1. rapid transit operations in an urban area that are not connected to the general railroad system of transportation;
2. tourist, scenic, historic or excursion operations, whether on or off the general railroad system of transportation;
3. operation of private cars, including business/office cars and circus trains; or
4. railroads that operate only on track inside an installation that is not part of the general railroad system of transportation.

Design and Construction of Passenger Railroad Rolling Stock

1. Materials

1.1 Austenitic stainless steel

Where austenitic stainless steel is required for structural use, it shall be in accordance with APTA-PR-CS-S-004-98.

1.2 High-strength low-alloy steel (HSLA)

Where HSLA steel structural shapes, plates, and bars are required, such parts shall, as a minimum, conform to ASTM A588. Plate may alternatively conform to ASTM A572, ASTM A1066, ASTM A514, ASTM A710 or EN-10025. General requirements for delivery of HSLA shapes, plates and bars shall be as required by ASTM A6.

Cold- and hot rolled HSLA sheet and strip shall, as a minimum, conform to the requirements of ASTM A606. Sheet and strip may alternatively conform to ASTM A1011. General requirements for delivery of HSLA sheet and strip shall be as required by ASTM A568 or ASTM A749, as applicable.

Welded HSLA steel shall develop minimum 15 ft-lbf (20 J) Charpy V-notch impact strength in the coarse grain heat-affected zone (CGHAZ) 1 mm from the fusion area at −20 °F (−30 °C).

Other HSLA steels that meet or exceed these minimum requirements may be used by agreement between the Manufacturer and the Purchaser. In any case, HSLA steels shall be applied strictly in accordance with the governing ASTM International or equivalent specification.

1.3 Aluminum

Where aluminum is required for structural use, it shall be in accordance with APTA-PR-CS-S-015-99.

1.4 Other materials

Materials other than those discussed in this standard may be used by agreement between the Manufacturer and the Purchaser. The Manufacturer and the Purchaser shall agree on the criteria for determining that alternative materials meet the strength and performance goals of this standard.

2. Structural safety and crashworthiness requirements

Unless otherwise stated, AW0 (empty, ready-to-run) weight shall be assumed for the load conditions defined in this section.

2.1 Static end-compression strength (49 CFR 238.203)

2.1.1 Passenger equipment without pushback couplers

Passenger equipment without pushback couplers shall meet the following end compression strength requirements:

a) Carbody structure shall be designed to resist a minimum static end-compression load of 800,000 lbf (3560 kN), applied longitudinally on the centerline of draft to the coupler or drawbar anchor of an empty, ready-to-run carbody.
b) For all equipment except non-passenger-carrying locomotives, carbody structure shall also be designed to resist a minimum end-compression load of 500,000 lbf (2224 kN) applied over an area not exceeding 6 in. (152 mm) high by 24 in. (610 mm) wide, centered vertically and horizontally on the underframe end sill or buffer beam construction.

2.1.2 Passenger equipment with pushback couplers

Passenger equipment with pushback couplers shall meet the following end compression strength requirements:

a) Carbody structure shall be designed to resist a minimum static end-compression load of 800,000 lbf (3560 kN), applied longitudinally on the centerline of draft to the coupler or drawbar anchor of an empty, ready-to-run carbody.
b) Carbody structure shall also be designed to resist a minimum end-compression load of 800,000 lbf (3560 kN) applied over an area not exceeding 6 in. (152 mm) high by 24 in. (610 mm) wide, centered vertically and horizontally on the underframe end sill or buffer beam construction.
c) The coupler or drawbar pushback load shall not exceed 800,000 lbf (3560 kN), including the operation of all energy-absorbing features. Reference APTA-PR-CS-RP-019-12 for recommended practices for pushback couplers.

2.1.3 Acceptance criteria

a) Static end-compression strength shall be verified by analysis and testing.
b) The acceptance criterion for each design load case shall be no permanent deformation in the carbody structure.
c) It is recommended that highly localized yielding or elastic buckling, which does not otherwise compromise the ability of the affected structure to meet the requirements of this standard and of the corresponding contract technical requirements, be permitted on a case-by-case basis as agreed by the Manufacturer and Purchaser.
d) When overloaded in compression, the body structure of passenger equipment shall be designed, to the maximum extent possible, to fail by buckling or crushing, or both, of structural members rather than by fracture of structural members or failure of structural connections.

2.2 Transverse strength requirements

2.2.1 General

The transverse strength requirements of this section shall apply to MU cars, cab cars, other cars and cabs of non-passenger-carrying locomotives.

2.2.2 Side strength

2.2.2.1 Side structure framing and sheathing

2.2.2.1.1 Framing (49 CFR 238.217[a])

The sum of the section moduli in cubic inches (cubic millimeters) about a longitudinal axis, taken at the weakest horizontal section between side sill and roof rail, of all posts on each side of the car located between the body corner posts shall be not less than 0.30 cu. in. (16.4 mm^3) multiplied by the distance in feet (millimeters) between the centers of end panels, and by the ratio of 32,000 psi (221 MPa) to the yield strength of the material used.

The sum of the section moduli, in cubic inches (cubic millimeters) about a transverse axis, taken at the weakest horizontal section between side sill and roof rail, of all side frame posts, braces and pier panels, to the extent they exist, on each side of car located between body corner posts shall be not less than 0.20 cu. in. (11.0 mm^3) multiplied by the distance in feet (millimeters) between the centers of end panels, and by the ratio of 32,000 psi (221 MPa) to the yield strength of the material used.

The section modulus for each post about each specified axis shall be calculated independently at the centroid of that post. The sum of the section moduli of all posts on each side of the car about the specified axis is calculated independently for the left and right sides of the car by adding the section moduli for all posts on the respective side of the car. This summation is to be repeated on each side of the car for each specified axis. The weakest horizontal section for each axis is the horizontal plane where the sum of the section moduli for all posts on the same plane is the lowest about that axis.

The center of an end panel shall be considered as the point midway between the center of the body corner post and the center of the adjacent side post.

2.2.2.1.2 Sheathing (49 CFR 238.217[b])

Outside sheathing of mild steel, with minimum 32,000 psi (221 MPa) yield strength, when used flat without reinforcement (other than side posts) in a side frame, shall not be less than ⅛ in. (3 mm) nominal thickness. Reinforcements and/or materials of higher yield strengths may be used to meet this requirement, provided that the sum of the shear capacity (0.577 × Area × Yield) of the reinforced structure, based on the yield strength of the material, is equivalent to the shear capacity of a ⅛ in. (3 mm) thick plate with a 32,000 psi (221 MPa) yield strength.

2.2.2.2 Side loads

2.2.2.2.1 Rollover (49 CFR 238.215 [a])

Except for switcher-cab locomotives, carbody structures shall be designed to rest on their sides, uniformly supported by the roof rail at the top of the side frame, by the side sill at the bottom of the side frame and, if a multilevel car, the longitudinal member at the edges of intermediate floors. The allowable stress shall be the lesser of one-half yield and one-half the critical buckling stress. Structural analysis shall be performed to demonstrate compliance with this requirement.

Switcher-cab locomotives shall be designed to provide a survivable volume in the operator’s cab with the locomotive lying on its side. Analysis shall show that the locomotive is capable of lying on its side supported along the length of the side sill and at the roof line by structure or major components most likely to contact the ground in a rollover incident where the unit comes to rest on its side. Under the action of the resulting applied load, deformation of cab structure shall be permitted as long as a survivable volume is maintained in the operator’s cab.

2.2.2.2.2 Side impact

Vehicle body structures shall be designed to resist an inward-directed load of 40,000 lbf (178 kN) applied to the bottom cords ("side sill") and, except for non-passenger-carrying locomotives, 7,000 lbf (31 kN) applied below the side window(s). These loads shall be applied separately over an area 6 in. (152 mm) high by 8 ft (2.4 m) long at the weakest section along the length of the car. For multilevel vehicles, the 40,000 lbf (178 kN) requirement applies to the mezzanine and lower levels separately, and the 7,000 lbf (31 kN) requirement applies to each level separately.

The connection of the side frame to the roof and underframe shall be designed to support these loads.

The allowable stress shall be the lesser of the yield strength and the critical buckling strength, with local yielding of the side sheathing at the belt rail and the side sill allowed. In addition, in door pocket areas where door panel guideways compromise the strength of the affected members, it shall be permissible for the structure outboard the guideway to crush inward and bear on the inboard structure of the underframe in resisting the required loads.

At doorways, regardless of width, including doorways greater than 8 ft (2.4 m) wide, an assumption that all cases of the load spanning the door opening are represented by one-half the required load applied to and resisted by each of the major posts at the edges of the door opening shall be permitted.

Structural analysis shall be performed to demonstrate compliance with this requirement.

2.3 End frame

The strength requirements for the collision posts and the supporting structure are defined in Section 2.3.1 and for the corner posts and supporting structure in Section 2.3.2. These strength requirements are intended to ensure that all connections to the carbody supporting structure of the collision and corner posts be designed to resist failure as the posts undergo plastic bending.

If the end frame has an anti-telescoping plate (A-T plate), then the effects of the A-T plate on the roof-post connection shall be considered.

2.3.1 Collision posts

2.3.1.1 General

This standard outlines the minimum structural design requirements for collision posts at the ends of occupied vehicles. The end of a vehicle that is designed to lead a train must protect occupants of that vehicle from the intrusion of objects the train has struck in a collision. As such, higher strength requirements are necessary for the lead ends of such vehicles.

The requirements of this standard are intended to result in an energy-absorbing end structure above the underframe. Therefore, requirements for collision posts in the following sections include the ability of the post to absorb a significant amount of energy by undergoing severe deformation without failure of the post or its connections during an overloading condition.

2.3.1.2 Non-passenger-carrying locomotives

2.3.1.2.1 Cab-end collision posts

Cab-ends of non-passenger-carrying locomotives and non-cab ends of locomotives with a hostler station shall have structural collision posts meeting the requirements outlined in this section.

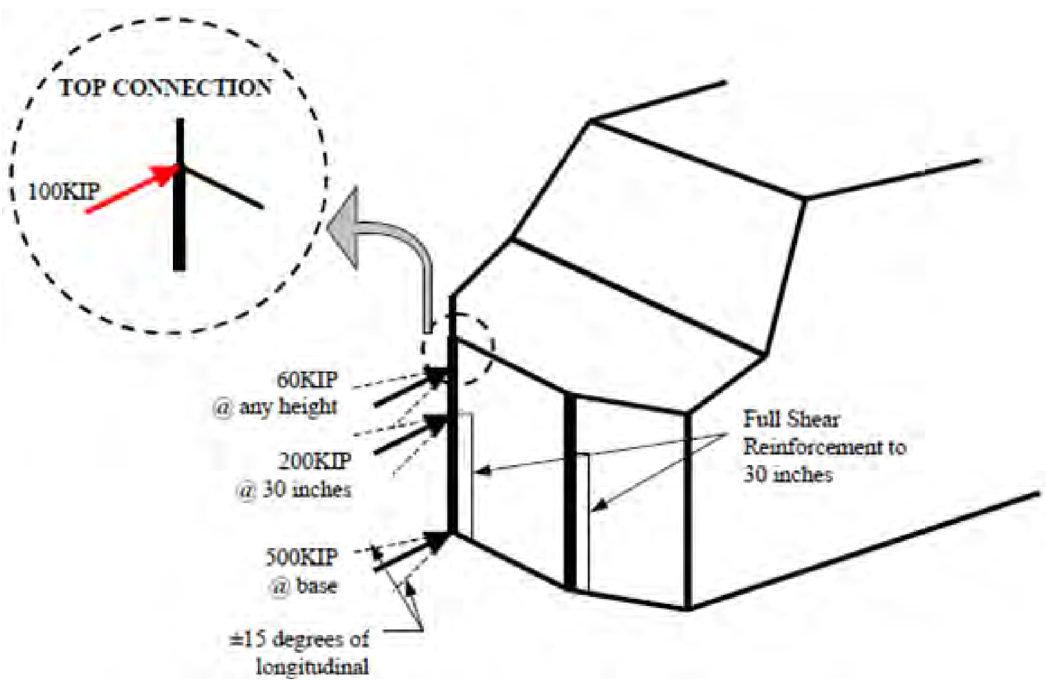
There shall be two collision posts extending from the underframe to a height within 6 in. (152 mm) from the bottom of the windshield, or alternatively at least 24 in. above the finished cab floor. They shall be located at the approximate one-third points across the width of the vehicle and shall, in their entirety, be forward of the seating position of any crew member. Each collision post, acting together with the supporting carbody structure, and intervening connections shall resist each one of the following horizontal inward loads individually applied at any angle within 15 deg. of the longitudinal axis (see **Figure 1**):

a) Minimum 500,000 lbf (2224 kN) applied at a point even with the top of the underframe, without exceeding the ultimate shear strength of the post (based on the shear area of the post, which is depth of the post times the thickness of the webs).
b) Minimum 200,000 lbf (890 kN) applied at a point 30 in. (762 mm) above the top of the underframe, without exceeding the ultimate strength.
c) Minimum 60,000 lbf (267 kN) applied anywhere along the post, including the top connection, above the top of the underframe, without permanent deformation of the post or supporting structure.
d) The top connection of the collision post (at the roof structure or the structure below the windshield, whichever applies) shall be designed to resist each of the following individually applied ultimate loads:
    - 100,000 lbf (445 kN) longitudinal shear load

The top connection loads specified in d) above are to be used to design the strength of the connections and not the supporting structure.

The area properties of the collision posts, including any reinforcement required to provide the specified 500,000 lbf (2224 kN) shear strength at the top of the underframe, shall extend from the bottom of the end sill to at least 30 in. (762 mm) above the top of the underframe.

FIGURE 1
Schematic of Collision Post Loads for Non-Passenger-Carrying Locomotive



Each collision post and any shear reinforcement, if used, shall be welded to the top and bottom plates of the end sill with welded joints qualified to the applicable AWS or CWB code, or equivalent recognized standard.

2.3.1.2.2 Non-cab-end collision posts

Non-passenger-carrying locomotives that do not have a hostler station at the non-cab end or "B" end of the locomotive are not required to have structural collision posts.

2.3.1.2.3 Alternative requirements for cab-end collision posts (49 CFR 238 Appendix F)

As an alternative to the requirements of Section 2.3.1.2.1, cab ends may be designed to meet the Alternative Requirements for Collision Posts provided in Appendix F to 49 CFR 238. The collision scenario shall involve a vehicle at AW0 (empty, ready-to-run weight) and an object with a recommended weight of 10,000 lbs. (4536 kg). The impact speed shall be adjusted to achieve a minimum impact energy of 135,000 ft-lb (0.18 MJ). The object weight may be adjusted to achieve higher impact speeds with the same impact energy, as agreed by the Purchaser and Manufacturer.

Conformance with the requirements of this section shall be demonstrated through analysis. The dynamic analysis shall be validated against the required quasi-static elastic-plastic testing of the front-end structure.

2.3.1.3 Cab cars

2.3.1.3.1 Cab-end collision posts (49 CFR 238.211[c])

Except as allowed by Section 2.3.1.3.2, cab ends of flat-end cab cars shall have structural collision posts meeting the requirements outlined in this section. There shall be two full-height collision posts extending from the underframe to the cant rail or roofline. They shall be located at the approximate one-third points across the width of the vehicle and shall, in their entirety, be forward of the seating position of any crew member or passenger.

Each collision post, acting together with the supporting carbody structure, and intervening connections shall resist the horizontal inward loads defined in sections a), b), and c) below, individually applied at any angle within 15 deg. of the longitudinal axis (see **Figure 2**). Analysis shall be performed to demonstrate compliance with all of the following requirements. A load distribution device may be used between the loading ram and post that is not greater than 6 in. (152 mm) high and wide enough to distribute the load directly into the post webs, but not more than 36 in. (914 mm) wide.

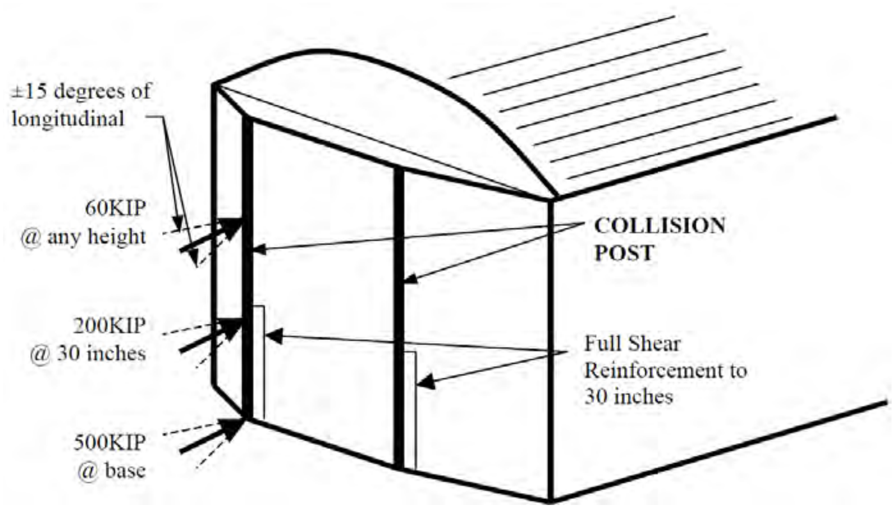
a) Minimum 500,000 lbf (2224 kN), applied such that the bottom of the load is even with the top of the underframe, without exceeding the ultimate shear strength of the post. If manual calculations are used for analysis, they shall be based upon the shear area of the post, which is the depth of the post in the direction of loading times the thickness of the webs. The load shall be applied exclusively to the collision post and may not be applied to any part of the underframe structure.
b) Minimum 200,000 lbf (890 kN) applied centered at a height of 30 in. (762 mm) above the top of the underframe, without exceeding the ultimate strength of the post or supporting structure.
c) Minimum 60,000 lbf (267 kN) applied at any height along the post, including the top connection, above the top of the underframe, without permanent deformation of the post or supporting structure.
d) Each collision post shall be capable of absorbing a minimum of 135,000 ft-lb (0.18 MJ) of plastic energy when loaded longitudinally, centered at a height of 30 in. (762 mm) above the top of the underframe. At the moment that the collision post has absorbed this minimum energy:
    - The post shall not permanently deflect more than 10 in. (254 mm) into the operator's cab or passenger seating area.
    - There shall be no complete separation of the post, its connection to the underframe, or its connection to either the roof structure or A-T plate (if used).

Testing shall be performed to demonstrate compliance with paragraph d) above.

The area properties of the collision posts, including any reinforcement required to provide the specified 500,000 lbf (2224 kN) shear strength at the top of the underframe, shall extend from the bottom of the end sill to at least 30 in. (762 mm) above the top of the underframe.

Each collision post and any shear reinforcement, if used, shall be welded to the top and bottom plates of the end sill with welded joints qualified to the applicable AWS or CWB code, or equivalent recognized standard.

FIGURE 2
Schematic of Collision Post Loads for the Cab End of Cab Cars



2.3.1.3.2 Alternative requirements for cab-end collision posts (49 CFR 238 Appendix F)

As an alternative to the requirements of Section 2.3.1.3.1, cab ends may be designed to meet the Alternative Requirements for Collision Posts provided in Appendix F to 49 CFR 238. The collision scenario shall involve a vehicle at AW0 (empty, ready-to-run weight) and an object with a recommended weight of 10,000 lbs. (4536 kg). The impact speed shall be adjusted to achieve a minimum impact energy of 135,000 ft-lb (0.18 MJ). The object weight may be adjusted to achieve higher impact speeds with the same impact energy, as agreed by the Purchaser and Manufacturer.

Conformance with the requirements of this section shall be demonstrated through analysis. The dynamic analysis shall be validated against the required quasi-static elastic-plastic testing of the front-end structure.

2.3.1.3.3 Non-cab-end collision posts

The non-cab ends of cab cars shall have structural collision posts meeting the requirements of Section 2.3.1.4.

2.3.1.4 Coach car collision posts (49 CFR 238.211[a])

Coach cars shall have structural collision posts meeting the requirements outlined in this section. There shall be two full-height collision posts extending from the underframe to the cant rail or roofline. They shall be located at the approximate one-third points across the width of the vehicle.

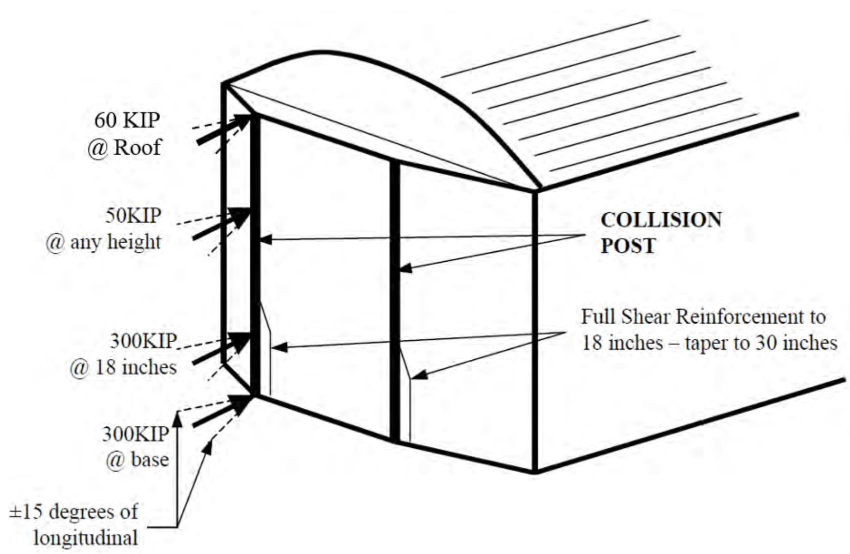
Each collision post, acting together with supporting carbody structure, and intervening connections shall resist each one of the following horizontal inward loads individually applied at any angle within 15 deg. of the longitudinal axis (see **Figure 3**). Analysis shall be performed to demonstrate compliance with all of the following requirements. Testing shall be performed to demonstrate compliance with the elastic portion of the following requirements. A load distribution device may be used between the loading ram and post that is not greater than 6 in. (152 mm) high and wide enough to distribute the load directly into the post webs, but not more than 36 in. (914 mm) wide.

a) Minimum 300,000 lbf (1334 kN), applied such that the bottom of the load is even with the top of the underframe, without exceeding the ultimate shear strength of the post. If manual calculations are used for analysis, they shall be based upon the shear area of the post, which is the depth of the post in the direction of loading times the thickness of the webs. The load shall be applied exclusively to the collision post and may not be applied to any part of the underframe structure.
b) Minimum 300,000 lbf (1334 kN) centered at a height of 18 in. (457 mm) above the top of the underframe, without exceeding the ultimate strength of the post and supporting structure.
c) Minimum 50,000 lbf (222 kN) applied anywhere along the post, including the top connection, above the top of the underframe, without permanent deformation of the post and supporting structure.
d) Minimum 60,000 lbf (267 kN) applied such that the top of the load is even with the attachment to the roof structure, without exceeding the ultimate strength of the post or supporting structure. The load shall be applied entirely to the collision post and may not be applied in any part to the roof structure.
e) The collision posts shall be designed so that if overloaded longitudinally at a point 30 in. (762 mm) above the underframe, the post will fail beginning with bending or buckling in the post and the post will continue in the plastic bending mode until its ultimate capacity has been developed. The connections of the post to the supporting structure shall support the post at its ultimate capacity.

The area properties of the collision posts, including any reinforcement required to provide the specified 300,000 lbf (1334 kN) shear strength at the top of the underframe, shall extend from the bottom of the end sill to at least 18 in. (457 mm) above the top of the underframe and then taper to a point 30 in. (762 mm) above the top of the underframe.

Each collision post and any shear reinforcement, if used, shall be welded to the top and bottom plates of the end sill with welded joints qualified to the applicable AWS or CWB code, or equivalent recognized standard.

FIGURE 3
Schematic of Collision Post Loads for Coach Cars



2.3.1.5 Permanently and semi-permanently coupled articulated cars

If a car is to be used within a permanently or semi-permanently coupled articulated consist, and provided that the intercar coupling meets the climb, bypass and overturn requirements of Section 2.5 of this standard, the collision post requirements outlined above apply only to the ends of the assembly of units, not to each end of each unit so joined. The requirements of 49 CFR 238.211(d) for documentation and analysis apply to this configuration.

The structural requirements for the collision posts at the end of this assembly of units will depend on the configuration of the trainset. If the end of the assembly of units is a non-passenger-carrying locomotive or power car, then the requirements of Section 2.3.1.2.1 apply. If the end of the assembly of units is at the lead end of the trainset (i.e., similar to a cab car), then the requirements of Sections 2.3.1.3.1 or 2.3.1.3.2 apply. If the end of the assembly of units is not at the lead end of the trainset, then the requirements of Section 2.3.1.4 apply.

2.3.2 Corner posts

2.3.2.1 General

All passenger equipment shall have at each end of the vehicle two structural corner posts, located ahead of the occupied volume. The corner posts shall extend from the bottom of the underframe structure to the bottom of the roof structure.

The requirements of this standard are intended to result in an energy-absorbing end structure above the underframe. Therefore, requirements for corner posts in the following sections include the ability of the post to absorb a significant amount of energy by undergoing severe deformation without failure of the post or its connections during an overloading condition.

2.3.2.2 Non-passenger-carrying locomotives corner posts

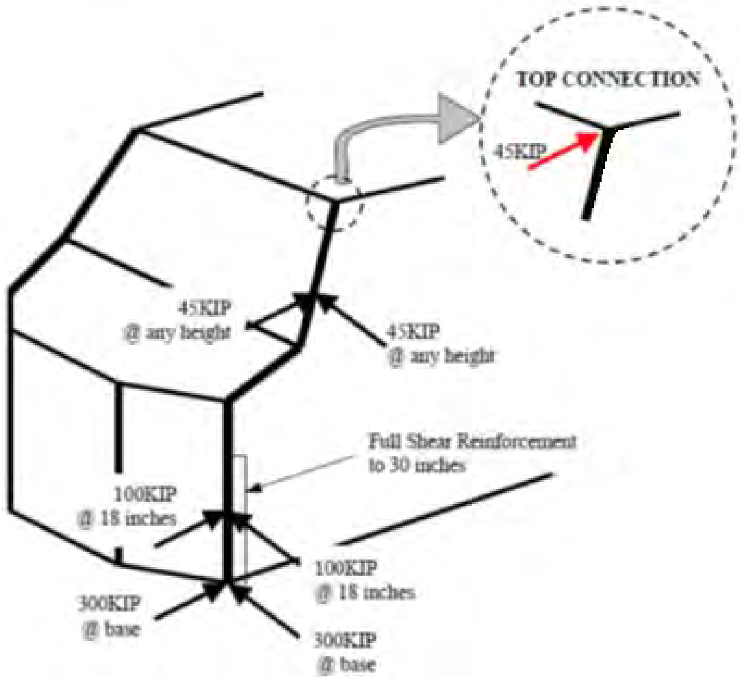
Cab ends of non-passenger-carrying locomotives and non-cab ends of locomotives with a hostler station shall have structural corner posts meeting the requirements outlined in this section. Each corner post, acting together with supporting carbody structure, and intervening connections shall resist each one of the following horizontal loads individually applied toward the inside of the vehicle in any direction from longitudinal to transverse (see **Figure 4**):

a) Minimum 300,000 lbf (1334 kN) applied at a point even with the top of the underframe, without exceeding the ultimate shear strength of the post (based on the shear area of the post, which is depth of the post times the thickness of the webs).
b) Minimum 100,000 lbf (445 kN) applied at a point 18 in. (457 mm) above the top of the underframe, without permanent deformation.
c) Minimum 45,000 lbf (200 kN) applied anywhere between the top of the post at its connection to the roof structure and the top of the underframe, without permanent deformation of the post or the supporting structure.
d) The connection of the corner post to the roof structure shall be designed to resist each of the following individually applied ultimate loads:
    - 45,000 lbf (200 kN) longitudinal shear load

The roof connection loads specified in d) above are to be used to design the strength of the connections and not the supporting structure.

The area properties of the corner post, including any reinforcement required to provide the specified 300,000 lbf (1334 kN) shear strength at the top of the underframe, shall extend from the bottom of the end sill to at least 30 in. (762 mm) above the top of the underframe.

FIGURE 4
Schematic of Corner Post Loads for Non-Passenger-Carrying Locomotive



Each corner post and any shear reinforcement, if used, shall be welded to the top and bottom plates of the end sill with welded joints qualified to the applicable AWS or CWB code, or equivalent recognized standard.

Corner posts in non-passenger-carrying locomotives with isolated cabs may be discontinuous at the boundary of the isolated cab but shall otherwise meet the requirements of this section for corner posts. A design incorporating discontinuous posts may require intermediate supports for the portions of the corner posts in the locomotive platform structure and in the isolated cab, and limit stops on the possible displacement of the isolated cab.

2.3.2.2.1 Alternative requirements for cab-end corner posts (49 CFR 238 Appendix F)

As an alternative to the requirements of Section 2.3.2.2, cab ends may be designed to meet the Alternative Requirements for Corner Posts provided in Appendix F to 49 CFR 238. The collision scenario shall involve a vehicle at AW0 (empty, ready-to-run weight) and an object with a recommended weight of 9,000 lbs. (4,082 kg). The impact speed shall be adjusted to achieve a minimum impact energy of 120,000 ft-lb (0.16 MJ). The object weight may be adjusted to achieve higher impact speeds with the same impact energy, as agreed by the Purchaser and Manufacturer.

Conformance with the requirements of this section shall be demonstrated through analysis. Where feasible, elastic–plastic testing of the front end structure shall be performed to validate the analysis results.

2.3.2.3 Cab cars

2.3.2.3.1 Cab-end corner posts (49 CFR 238.213[b])

The cab ends of cab cars shall have structural corner posts meeting the requirements outlined in this section. Each corner post, acting together with supporting carbody structure, and intervening connections shall resist the horizontal loads in paragraphs a), b) and c), individually applied toward the inside of the vehicle in any direction from longitudinal to transverse (see **Figure 5**). Analysis shall be performed to demonstrate compliance with all of the following requirements. A load distribution device may be used between the loading ram and post that is not greater than 10 in. (254 mm) high by 10 in. (254 mm) wide.

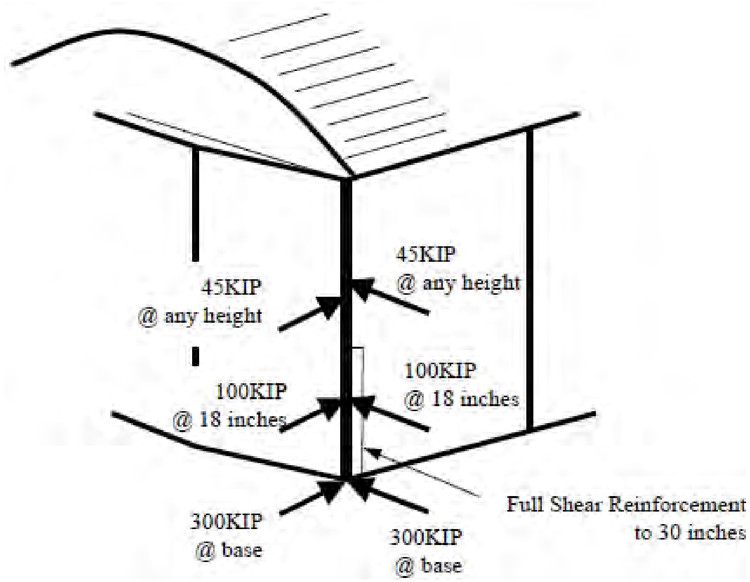
a) Minimum 300,000 lbf (1334 kN) applied such that the bottom of the load is even with the top of the underframe, without exceeding the ultimate shear strength of the post. If manual calculations are used for analysis, they shall be based upon the shear area of the post, which is the depth of the post in the direction of loading times the thickness of the webs. The load shall be applied exclusively to the corner post and may not be applied to any part of the underframe structure.
b) Minimum 100,000 lbf (445 kN) centered at a height of 18 in. (457 mm) above the top of the underframe, without permanent deformation of the post or supporting structure.
c) Minimum 45,000 lbf (200 kN) applied anywhere between the top of the post at its connection to the roof structure and the top of the underframe, without permanent deformation of the post or supporting structure.
d) Each corner post on a cab car shall be capable of absorbing a minimum of 120,000 ft-lb (0.16 MJ) of plastic energy when loaded longitudinally at a height of 30 in. (762 mm) above the top of the underframe. At the moment that the corner post has absorbed this minimum energy:
    - The post shall not permanently deflect more than 10 in. (254 mm) into the operator's cab or passenger seating area.
    - There shall be no complete separation of the post, its connection to the underframe, structural shelf, sidewall structure, or its connection to either the roof structure or A-T plate (if used).

Testing shall be performed to demonstrate compliance with the elastic portion of paragraph d).

The area properties of the corner post, including any reinforcement required to provide the specified 300,000 lbf (1334 kN) shear strength at the top of the underframe, shall extend from the bottom of the end sill to at least 30 in. (762 mm) above the top of the underframe.

Each corner post and any shear reinforcement, if used, shall be welded to the top and bottom plates of the end sill with welded joints qualified to the applicable AWS or CWB code, or equivalent recognized standard.

FIGURE 5
Schematic of Corner Post Loads for Cab Ends of Cab Cars



2.3.2.3.2 Non-cab-end corner posts

The non-cab ends of cab cars shall have structural corner posts meeting the requirements outlined in Section 2.3.2.3.4.

2.3.2.3.3 Cab-end non-operator side of cab – alternate requirements (49 CFR 238.213(c))

Cab cars that use low-level passenger boarding at the non-operating side of the cab end and are unable to meet the requirements outlined in Section 2.3.2.3.1 shall meet the following alternate structural requirements for the corner post and the adjacent body corner post (post on the inboard side of the stepwell) at the non-operating side of the cab (see **Figure 6**). Analysis shall be performed to demonstrate compliance with all of the following requirements. Testing shall be performed to demonstrate compliance with the elastic portion of the following requirements. A load distribution device may be used between the loading ram and post that is not greater than 10 in. (254 mm) high by 10 in. (254 mm) wide.

2.3.2.3.3.1 Severe deformation

The corner post and the body corner post on a cab car shall be capable of absorbing a minimum of 120,000 ft-lb (0.16 MJ) of energy, in accordance with the following formula, when loaded longitudinally at a height of 30 in. (762 mm) above the top of the underframe:

$$E_{min} = ECP + EBCP$$

where: E_{min} = minimum total energy absorbed = 120,000 ft-lb (0.16 MJ)
ECP = energy absorbed by the corner post
EBCP = energy absorbed by the body corner post

At the moment the corner post fails to resist any further load due to complete separation of the post and/or its supporting structure, the corresponding energy absorbed by the corner post shall be calculated (ECP). The load shall then be applied to the body corner post to absorb the remaining energy (EBCP).

At the moment that the body corner post has absorbed the remaining minimum energy:

- The body corner post shall not permanently deflect more than 10 in. (254 mm) into the passenger seating area and,
- There shall be no complete separation of the body corner post, its connection to the underframe, sidewall structure, or its connection to either the roof structure or A-T plate (if used).

2.3.2.3.3.2 Corner post

The corner post of cab cars meeting the alternate requirements, acting together with supporting carbody structure, and intervening connections shall resist each one of the following horizontal loads individually applied toward the inside of the vehicle (see **Figure 6**):

a) Minimum 150,000 lbf (667 kN) applied longitudinally such that the bottom of the load is even with the top of the underframe, without exceeding the ultimate shear strength of the post (based on the shear area of the post, which is the depth of the post in the direction of loading times the thickness of the webs). The load shall be applied exclusively to the corner post and may not be applied to any part of the underframe structure.
b) Minimum 30,000 lbf (133 kN) applied longitudinally centered at a height of 18 in. (457 mm) above the top of the underframe, without permanent deformation of the post or supporting structure.
c) Minimum 30,000 lbf (133 kN) applied longitudinally such that the top of the load is even with the attachment to the roof structure, without permanent deformation of the post or supporting structure. The load shall be applied entirely to the corner post and may not be applied in any part to the roof structure.
d) Minimum 20,000 lbf (89 kN) applied longitudinally anywhere between the top of the post at its connection to the roof structure and the top of the underframe, without permanent deformation of the post or supporting structure.
e) Minimum 300,000 lbf (1334 kN) applied transversely such that the bottom of the load is even with the top of the underframe, without exceeding the ultimate shear strength of the post (based on the shear area of the post, which is the depth of the post in the direction of loading times the thickness of the webs). The load shall be applied entirely to the corner post and may not be applied in any part to the underframe structure.
f) Minimum 100,000 lbf (445 kN) applied transversely, centered at a height of 18 in. (457 mm) above the top of the underframe, without permanent deformation of the post or supporting structure.
g) Minimum 45,000 lbf (200 kN) applied transversely anywhere between the top of the post at its connection to the roof structure and the top of the underframe, without permanent deformation of the post or supporting structure.

2.3.2.3.3.3 Body corner post

The body corner posts of cab cars meeting the alternate requirements, acting together with supporting carbody structure, and intervening connections shall resist each one of the following horizontal loads individually applied toward the inside of the vehicle (see **Figure 6**).

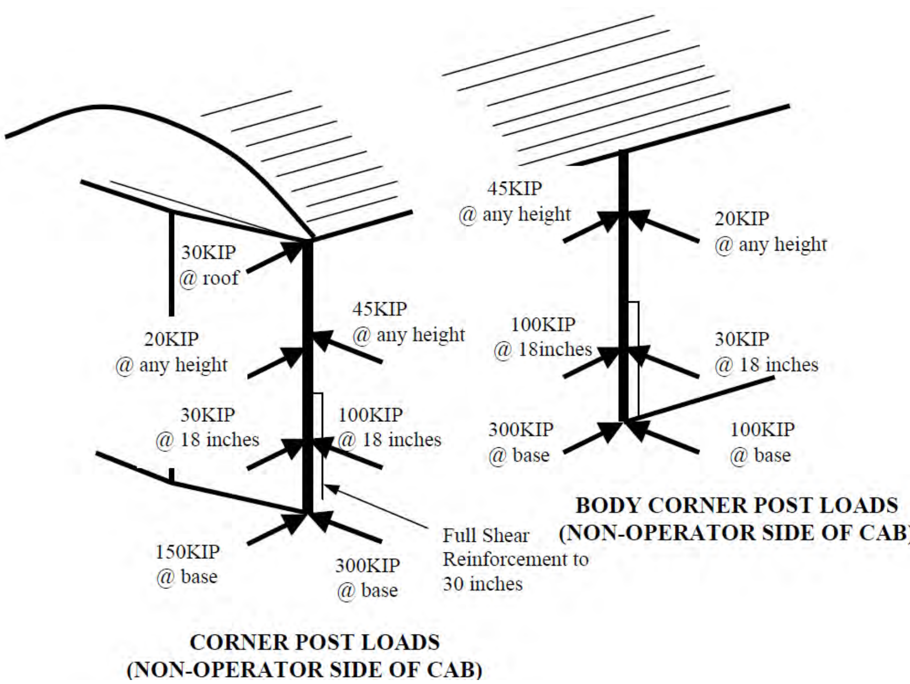
a) Minimum 300,000 lbf (1334 kN) applied longitudinally such that the bottom of the load is even with the top of the underframe, without exceeding the ultimate shear strength of the post (based on the shear area of the post, which is the depth of the post in the direction of loading times the thickness of the webs). The load shall be applied exclusively to the corner post and may not be applied to any part of the underframe structure.
b) Minimum 100,000 lbf (445 kN) applied longitudinally centered at a height of 18 in. (457 mm) above the top of the underframe, without permanent deformation of the post or supporting structure.

c) Minimum 45,000 lbf (200 kN) applied longitudinally anywhere between the top of the post at its connection to the roof structure and the top of the underframe, without permanent deformation of the post or supporting structure.
d) Minimum 100,000 lbf (445 kN) applied transversely such that the bottom of the load is even with the top of the underframe, without exceeding the ultimate shear strength of the post (based on the shear area of the post, which is the depth of the post in the direction of loading times the thickness of the webs). The load shall be applied entirely to the corner post and may not be applied in any part to the underframe structure.
e) Minimum 30,000 lbf (134 kN) applied transversely, centered at a height of 18 in. (457 mm) above the top of the underframe, without permanent deformation of the post or supporting structure.
f) Minimum 20,000 lbf (90 kN) applied transversely anywhere between the top of the post at its connection to the roof structure and the top of the underframe, without permanent deformation of the post or supporting structure.

The area properties of the corner post and body corner post, including any reinforcement required to provide the specified shear strength at the top of the underframe, shall extend from the bottom of the end sill or side sill to at least 30 in. (762 mm) above the top of the underframe.

Each corner post, and any shear reinforcement, if used, shall be welded to the top and bottom plates of the end sill with welded joints qualified to the applicable AWS or CSA code, or equivalent recognized standard.

FIGURE 6
Schematic of Corner Post and Body Corner Post Loads for MU and Cab Cars
(Cab End, Non-Operator Side Only with Step Well)



2.3.2.3.4 Alternative requirements for cab-end corner posts (49 CFR 238 Appendix F)

As an alternative to the requirements of Section 2.3.2.3.1, cab ends may be designed to meet the Alternative Requirements for Corner Posts provided in Appendix F to 49 CFR 238. The collision scenario shall involve a vehicle at AW0 (empty, ready-to-run weight) and an object with a recommended weight of 9,000 lbs. (4082 kg). The impact speed shall be adjusted to achieve a minimum impact energy of 120,000 ft-lb

(0.16 MJ). The object weight may be adjusted to achieve higher impact speeds with the same impact energy, as agreed by the Purchaser and Manufacturer.

Conformance with the requirements of this section shall be demonstrated through analysis. Where feasible, elastic–plastic testing of the front end structure shall be performed to validate the analysis results.

2.3.2.4 Coach car corner posts (49 CFR 238.213[a])

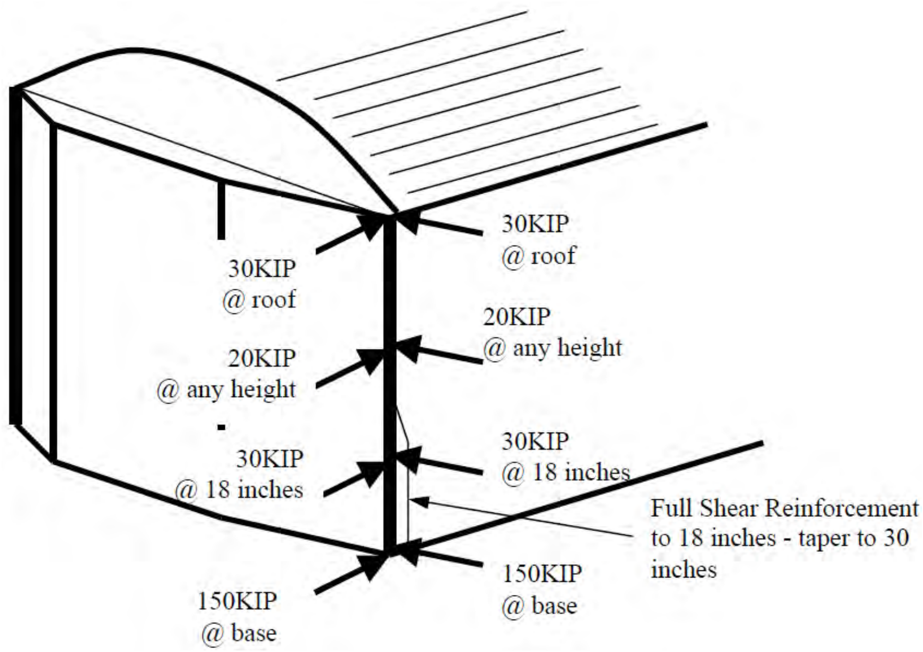
Each corner post, acting together with supporting carbody structure, and intervening connections shall resist each one of the following horizontal loads individually applied toward the inside of the vehicle in any direction from longitudinal to transverse (see **Figure 7**). Analysis shall be performed to demonstrate compliance with all of the following requirements. Testing shall be performed to demonstrate compliance with the elastic portion of the following requirements. A load distribution device may be used between the loading ram and post that is not greater than 10 in. (254 mm) high by 10 in. (254 mm) wide.

a) Minimum 150,000 lbf (667 kN) applied such that the bottom of the load is even with the top of the underframe, without exceeding the ultimate shear strength of the post (based on the shear area of the post, which is depth of the post in the direction of loading times the thickness of the webs). The load shall be applied exclusively to the corner post and may not be applied to any part of the underframe structure.
b) Minimum 30,000 lbf (133 kN) centered at a height of 18 in. (457 mm) above the top of the underframe, without permanent deformation of the post or supporting structure.
c) Minimum 30,000 lbf (133 kN) applied such that the top of the load is even with the point of attachment to the roof structure, without permanent deformation of the post or supporting structure.
d) Minimum 20,000 lbf (89 kN) applied anywhere between the top of the post at its connection to the roof structure and the top of the underframe, without permanent deformation of the post or the supporting structure.
e) The corner posts shall be designed so that if overloaded longitudinally at a point 30 in. (762 mm) above the underframe, the post will fail beginning with bending or buckling in the post and the post will continue in the plastic bending mode until its ultimate capacity has been developed. The connections of the post to the supporting structure shall support the post at its ultimate capacity.

The area properties of the corner posts, including any reinforcement required to provide the specified 150,000 lbf (667 kN) shear strength at the top of the underframe, shall extend from the bottom of the end sill to at least 18 in. (457 mm) above the top of the underframe, and shall then taper to a point at a level not less than 30 in. (762 mm) above the top of the underframe.

Each corner post and any shear reinforcement, if used, shall be welded to the top and bottom plates of the end sill with welded joints qualified to the applicable AWS or CSA code, or equivalent recognized standard.

FIGURE 7
Schematic of Corner Post Loads for Coach Cars



2.3.3 Horizontal framing members, MU cars, cab cars and other cars

End frame collision and corner posts may be connected by horizontal structural members as necessary to resist the lateral components of the design loads specified in Sections 2.3.1 and 2.3.2. In addition, an A-T plate may be used to connect the tops of the collision and corner posts.

Cab-end framing of cars with full or partial cabs shall include a horizontal structural member between the collision post and corner post on each side at a height equivalent to the bottom of the windshield. The structural shelf shall support a load of not less than 15,000 lbf (67 kN) applied horizontally, perpendicular to the member at any point on its span without permanent deformation of any part of the vehicle structure. Analysis shall be performed to demonstrate compliance with this requirement. Testing may be performed to validate the analysis results.

2.3.4 End frame sheathing, MU cars, cab cars and other cars; and non-passenger-carrying locomotives (49 CFR 238.209[a])

Cab-end frame sheathing of MU cars, cab cars and other cars with full or partial cabs shall have the following characteristics:

a) Equivalent to a ½ in. (13 mm) thick steel plate with a 25,000 psi (172 MPa) yield strength. Multiple skin/structural elements or materials of higher yield strengths may be used to meet this requirement, provided that the sum of the shear strengths of each element from the leading edge of the vehicle to a vertical plane just forward of the engineer's normal operating position, based on the yield strength of the material, is equivalent to the shear strength of a ½ inch (13 mm) thick plate with a 25,000 psi (172 MPa) yield strength.
b) Designed to inhibit the entry of fluids into the occupied cab area of the equipment. Fluid entry inhibition shall be provided by a continuously welded or continuously sealed metallic plate or sheet. An FRP mask alone is not sufficient to meet this requirement.
c) Connected to underlying framing members sufficient to develop the full strength of the sheathing.

The end frame sheathing does not include doors or forward-facing windows.

2.4 Roof

2.4.1 Roof framing and sheathing, all passenger equipment

a) The projected area on a horizontal plane, in units of square feet (square millimeters), of the portion of the roof supported by carlines divided by the sum of the section moduli in units of cubic inches (cubic millimeters) of the carlines at any longitudinal section shall not be more than 60 sq. ft/cu. in. (340 mm^{-1}).
b) Flat roof sheets of mild steel with 32 ksi (221 MPa) yield strength and without reinforcements, aside from the roof framing, shall be of a minimum thickness of 0.05 in. (1.3 mm). Metals of other strengths may be used of a thickness in inverse proportion to yield strength.
c) Metal roof sheets of a lesser thickness may be used, provided that the sheets are reinforced to produce at least an equivalent sectional area, on any lateral section, as the roof sheets specified in b).

2.4.2 Rollover, all passenger equipment (49 CFR 238.215[b])

Vehicles, except non-passenger-carrying locomotives with non-structural equipment hoods, shall be designed to rest on their roofs so that any structural damage in occupied areas is limited to roof sheathing and framing members. Deformation to the roof sheathing and framing is allowed to the extent necessary to permit the vehicle, including the weight of the trucks, to be uniformly supported directly on the top chords of the side frames and end frames. For this condition, the allowable stress for the structure of the occupied zones of the carbody shall be one-half yield or one-half the critical buckling stress, whichever is less. Structural analysis shall be performed to demonstrate compliance with this requirement.

Non-passenger-carrying locomotives with non-structural equipment hoods shall be designed such that in the event of a rollover, the operator's cab will maintain a survivable volume. The Manufacturer shall show by layout and calculation (classic or FEA) that the locomotive is capable of resting upside-down at two or more points of contact while simultaneously maintaining a survivable volume within the operator's cab. The points of contact may be a major piece of equipment (for example, the diesel engine and transformer), one end of the platform or the other (depending on the location of the center of gravity), or structural members added to satisfy this requirement. Deformation of equipment enclosures and operator's cab roof sheathing is allowed to the extent necessary to permit the vehicle to be supported as described. The allowable stress for structural members added to the structure specifically for this load case shall be one-half yield or one-half the critical buckling stress. The load applied to the structural members shall be determined from a static balance calculation, while the locomotive is upside-down, assuming only the truck adjacent to the operator's cab is still attached to the structure.

2.4.3 Other roof loads, all passenger equipment

Roof framing members and roof sheathing shall have sufficient strength to withstand, without permanent deformation, three loads of 250 lbf (1112 N) spaced 30 in. (760 mm) apart, each load distributed over an area no larger than 5 in. (127 mm) by 5 in. (127 mm), such as might be applied by maintenance personnel working on the roof. The placement of the loads shall be such as to produce the worst-case condition for the roof structure. Structural analysis shall be performed to demonstrate compliance with this requirement.

2.5 Climb, bypass and overturn resistance

2.5.1 General

At each end of each unit or car there shall be a structural arrangement designed to resist vertical climb loads, lateral bypass loads, and torsional loads resulting from the incipient overturning of one or more units in a consist. The vertical, lateral and torsional loads shall be considered as applied separately. The loads discussed in this section do not apply to couplers, only to the carbody structure that contains the couplers.

2.5.2 Passenger cars

2.5.2.1 Climb resistance (49 CFR 238.205[a])

Both ends of all passenger equipment shall have an anti-climbing system capable of resisting a vertical load (both upward and downward), which shall not be less than 100,000 lbf (445 kN). The acceptance criteria for this load condition shall be no permanent deformation of the anti-climbing system components, supporting carbody structure and intervening connections. Structural analysis shall be performed to demonstrate compliance with this requirement.

If using a coupling device (e.g., Type F interlocking, Type H tightlock, drawbars, semi-permanent couplers, articulation joints) to comply with this requirement, the load shall be applied at the interface points between the carbody structure and coupling device (e.g., buffer beam and coupler carrier). The reaction load at the pivot point of the draft gear shall be considered in the analysis. If the end of the car is equipped with a separate anti-climber (e.g., shelf-type or ribbed anti-climber), then the load shall be applied directly to the anti-climber.

Unless pushback couplers provide equivalent anti-climbing resistance at all points during the stroke, any vehicle end using a pushback coupler shall have a separate anti-climbing mechanism meeting the requirements of this section. If equipped with pushback coupler and separate anti-climber, the anti-climbers shall be engaged within the pushback coupler nonrecoverable stroke. Reference APTA-PR-CS-RP-019-12 for recommended practices for pushback couplers.

2.5.2.2 Bypass resistance

The lateral strength of the structural arrangement in both directions shall not be less than the minimum climb-resistance design strength in accordance with Section 2.5.2.1. Structural analysis shall be performed to demonstrate compliance with this requirement.

2.5.2.3 Overturn resistance

Unless the vehicle is designed and equipped with a pushback coupler, the coupler anchor and supporting carbody structure shall have sufficient strength to develop the ultimate torsional strength of the coupler, without permanent deformation of the coupler anchor and supporting carbody structure. The ultimate torsional strength of the coupler shall not be less than that of an equivalent coupler approved under APTA-PR-M-RP-003-98 using AAR Standard M-201 Grade C Steel. Structural analysis shall be performed to demonstrate compliance with this requirement. If a vehicle is equipped with a pushback coupler, then the coupler anchor and supporting structure shall have sufficient strength to develop the torsional capacity of the pushback coupler, as required by APTA PR-CS-RP-019.

2.5.2.4 Coupler and drawbar carrier and buffer beam (49 CFR 238.207)

The structural arrangement shall include a coupler carrier designed to resist a 100,000 lbf (445 kN) vertical downward thrust applied over an area equivalent to that of the coupler shank at any possible horizontal position of the coupler. The acceptance criteria for this condition shall be no permanent deformation of the coupler carrier, supporting carbody structure and intervening connections.

The structural arrangement shall be designed to resist the 100,000 lbf (445 kN) vertical upward thrust from the coupler for any horizontal position of the coupler. The acceptance criteria for this condition shall be no permanent deformation of the supporting carbody structure and intervening connections.

Structural analysis shall be performed to demonstrate compliance with these requirements.

2.5.3 Non-passenger-carrying locomotives

Bypass and overturn resistance of non-passenger-carrying locomotives shall be as required by Section 2.5.2.

Each non-passenger-carrying locomotive must be equipped with an anti-climber that extends to the approximate one-third points across the width on its cab end. Except for pushback couplers, the center of the anti-climber must extend to within 4 in. of the pulling face of the coupler with the draft gear fully compressed. The center of the anti-climber must extend no less than 10 in. from the locomotive front plate for its required width.

The anti-climber must be able to resist an upward or downward vertical force of 100,000 lb applied over a 12 in. width anywhere along the anti-climber perimeter. The load must be applied without exceeding the ultimate strength of the anti-climber.

Coupled non-passenger-carrying locomotives and passenger cars shall be equipped with a compatible anti-climbing system.

2.6 Truck to carbody attachment strength

2.6.1 General (49 CFR 238.219)

A mechanism for attaching the completely assembled truck, including the bolster, if used, to the carbody shall be provided in accordance with the requirements of this section. The requirements of sections 2.6.2 and 2.6.3 shall be considered as separate load cases. Structural analysis shall be performed to demonstrate compliance with these requirements.

2.6.2 Horizontal

The ultimate strength of the truck, attachment mechanism, and supporting carbody structure shall be sufficient to secure the entire truck to the carbody in a manner that will prevent separation of the truck from the carbody during derailments and collisions in which a horizontal load of minimum 250,000 lbf (1112 kN) is applied to the truck frame in any horizontal direction and oriented through the center of truck rotation at a vertical position defined by a horizontal plane that passes through the center of gravity (CG) of the complete truck assembly. The required resistance to a 250,000 lbf (1112 kN) horizontal load shall be available at any possible position of the truck in its vertical suspension travel, including the condition of the car raised off the track with the truck hanging from the car, and shall not depend upon external vertical loading.

2.6.3 Vertical

The vertical strength of the attachment mechanism shall provide a minimum factor of safety of 2, based on the yield strength of the structural material used in the truck, carbody and the elements of the attachment mechanism, during jacking or lifting of the carbody with the truck hanging from the carbody.

2.6.4 Truck rotation stops

If truck rotation stops are desired by the Purchaser, they should be arranged to limit truck rotation to a value that does not interfere with normal vehicle operation for any possible truck position between suspension stops, or with vehicle maintenance. The strength of the stops should be selected on the basis of the type of service, vehicle speed and weight, and a minimum value equivalent to 20,000 lbf (89 kN) at 4 ft (1.2 m) from the center of rotation of the truck is suggested.

2.7 Equipment attachment

2.7.1 General

This section contains minimum requirements for the static strength of attachment of major equipment to the carbody structure of railroad passenger equipment. The purpose of the requirements is to maximize the strength of attachment of the equipment to the extent possible within the parameters defined by the applicable performance requirements, to minimize the risk of the attachments failing prematurely in case of collision, derailment or other emergency.

Structural supports for passenger locomotives and equipment having a weight greater than 150 lb (667 N) shall conform to the requirements of this standard.

These requirements do not apply to seats and interior fittings in passenger and crew compartments; refer to latest revisions of APTA-PR-CS-S-016-99, “Row-to-Row Seating in Commuter Railcars,” APTA-PR-CS-S-011-99, “Cab Crew Seating Design and Performance,” and APTA-PR-CS-S-006-98, “Attachment Strength of Interior Fittings for Passenger Railroad Equipment.” These requirements do not apply to safety appliances required by 49 CFR 231; refer to APTA-PR-M-S-016-06, “Safety Appliances for Rail Passenger Cars.”

2.7.2 MU cars and passenger cars

2.7.2.1 Strength

The design static load factor for all underfloor and roof-mounted equipment, any portion of the equipment, equipment boxes, equipment hangers, standby supports, safety hangers, and the carbody supporting structure shall not be less than ±8g longitudinal, ±4g vertical, and ±4g lateral. The load shall be equal to the weight of the equipment times the appropriate load factor, applied at the center of gravity of the equipment, and each shall be combined with the vertical 1g down-load of the weight of the equipment. The static load factors shall be applied separately so there are a total of six load cases, one corresponding to each sense in each of the three directions combined with the weight of the equipment. The load for each case must be less than the ultimate strength of the component or connection. Structural analysis shall be performed to demonstrate compliance with these requirements.

For equipment mounted on or in roof hatches, the requirements shall apply to the mounting of the equipment to the hatch, and to the installation of the hatch in the carbody.

2.7.2.2 Safety hangers

Safety straps, hangers or other devices shall be used on all equipment weighing more than 150 lb mounted resiliently or rigidly with bolts in the load path.

2.7.2.3 Clearance

With the failure of any one of the attachments, the equipment shall remain within the clearance envelope of the vehicle as defined by the operating railroad.

Safety brackets, hangers and other similar devices shall be designed to carry the equipment within the clearance envelope under normal operating load conditions in case of failure of the primary attachment system.

2.7.2.4 Fasteners

It is recommended that equipment not be supported by bolts in the load path. Designs that incorporate transfer of load by brackets bearing directly on underframe members to the maximum extent possible are preferred.

2.7.2.5 Welding

Welding of equipment attachments shall be in accordance with the requirements of the applicable AWS or CWB code, or equivalent recognized standard.

2.7.3 Non-passenger-carrying locomotive

Non-passenger-carrying locomotives shall comply with Section 2.7.2, except that the design static load factors for equipment weighing more than 7500 lbf (34 kN) shall be not less than ±3g longitudinal, ±2g vertical and ±1.5g lateral, and the allowable stress for each load case as otherwise defined by Section 5.7.2 for equipment weighing more than 7500 lbf (34 kN) shall be yield strength.

2.8 Structural connections

As agreed between the Purchaser and Manufacturer, critical connections between structural members of the carbody shall be designed such that the strength of the connection exceeds the ultimate load-carrying capacity of the weakest member joined. This requirement shall apply to connections between primary carbody and truck structural members under the actions of the following emergency load cases: end-compression loads, end-frame collision post, corner post and structural shelf loads; side loads; rollover loads; climb, bypass and overturn loads; and the horizontal truck connection. The ultimate strength of the weaker member shall be calculated on the basis of overloading the member at the point of application of the emergency load.

3. Design loads and practices

3.1 Carbody vertical load

Except for non-passenger-carrying locomotives, the completely equipped, ready-to-run carbody shall be designed to carry its carbody weight (not including truck weight) supported on the trucks, plus a uniformly distributed maximum passenger load as agreed upon by the Purchaser and Manufacturer. The stresses in the carbody under vertical load shall not exceed the lesser of 50 percent of the guaranteed minimum material yield strength, or 100 percent of the buckling strength.

3.2 Carbody fatigue analysis

Except for non-passenger-carrying locomotives, the fatigue strength of the joints between major structural elements and areas with stress concentrations (such as door and window corners) shall be demonstrated using one of the following methods:

- Cumulative damage approach; the Manufacturer may use this approach if the track-induced load data are known. In this case, the required fatigue life is as agreed between the Purchaser and the Manufacturer.
- Endurance limit approach; the Manufacturer shall use a stress range as agreed between the Purchaser and the Manufacturer, but not less than 0.4 times the stress calculated for the maximum vertical load. If mean stress is accounted for in the fatigue analysis, it shall be equal to the stress calculated for the maximum vertical load. The design fatigue life shall be 10 million cycles. A lesser value may be used, if agreed to by the Purchaser and Manufacturer.

The Manufacturer shall use a codified methodology for evaluating fatigue. These include, but are not limited to, the following:

- AAR M1001-CII
- AWS D1.1, Structural Welding Code – Steel
- Aluminum Design Manual, The Aluminum Association

- DVS 1608, Design and Strength Assessment of Welded Structures from Aluminium Alloys in Railway Applications
- DVS 1612, Design and endurance strength assessment of welded joints with steels in rail vehicle construction
- BS 7608, Guide to fatigue design and assessment of steel products
- EN 1993-1-9, Design of steel structures – Part 1-9: Fatigue
- EN 1999-1-3, Design of aluminum structures – Part 1-3: Fatigue
- IIW-1823, Recommendations for Fatigue Design of Welded Joints and Components

The AISC Design Guide 27 on Structural Stainless Steel advises that guidance on estimating fatigue strength of carbon steels structures is applicable to austenitic and duplex stainless steels.

In cases for which the codes do not provide allowable fatigue stress for a particular material or fabrication detail, the Manufacturer shall conduct tests to determine the allowable fatigue stress. The methodology for establishing fatigue design allowables from the test results (i.e., survival, probability, and confidence interval) shall be as agreed between the Purchaser and Manufacturer.

As of this writing, APTA knows of no codes for the fatigue design of resistance welds. The Manufacturer shall conduct tests to determine the allowable fatigue loads for the materials, thicknesses and welding parameters to be used in the fabrication of the rail vehicle. Fatigue data from prior projects or from the technical literature may also be used, provided that the materials, thicknesses and welding parameters to be used in the fabrication of the subject rail vehicle are the same.

3.3 Carbody torsional loads

Except for non-passenger-carrying locomotives, the finished car at empty condition shall resist a three-point jacking case at most extreme outboard jacking locations, without permanent deformation and without damage to any component. Vertical deflection of the unsupported corner, choice of jacking points, and the presence or not of trucks shall be agreed to between Purchaser and Manufacturer.

The analysis model required to demonstrate compliance shall be validated against a test of the bare shell carbody with particular attention to torsional stiffness, in addition to stress evaluations. The bare carbody shell used for the torsion test may include a floor arrangement with shear stiffness and fastening equivalent to those of the finished floor.

3.4 Roof emergency access

3.4.1 All passenger equipment except non-passenger-carrying locomotives

All passenger equipment except non-passenger-carrying locomotives shall be provided with a minimum of two roof soft spots or a roof access hatch to provide access from the exterior of the vehicle to the occupied areas of the passenger car in the event of complete access blockage of all side doors and end doors after a rollover.

Roof soft spots shall be identified in accordance with the requirements of APTA-PR-PS-S-006-23.

3.4.2 Non-passenger-carrying locomotives

All non-passenger-carrying locomotives shall be provided with a single roof soft spot or roof access hatch above the cab to provide access from the exterior of the vehicle to the occupied areas of the passenger car in the event of complete access blockage of all side doors and end doors after a rollover.

Roof soft spots and roof access hatches shall be identified in accordance with the requirements of APTA-PR-PS-S-006-23.

3.4.3 Location

3.4.3.1 All passenger equipment except non-passenger-carrying locomotives

One roof soft spot or roof access hatch shall be located wholly on each side of the vertical plane through the longitudinal centerline of the vehicle. The two roof soft spots or roof access hatches shall be located as far apart laterally as practical in order to place one access means as close as possible to the track bed when the vehicle is overturned through 90 deg.

One roof soft spot or roof access hatch shall be located wholly on each side of the vertical plane through the lateral centerline of the vehicle.

3.4.3.2 Non-passenger-carrying locomotives

One roof soft spot or roof access hatch shall be located centrally on the vertical plane through the longitudinal centerline of the vehicle. The roof soft spot or roof access hatch shall be located as practical centrally above the cab.

3.4.4 Opening size

Each roof soft spot or roof access hatch shall have at least the following minimum clear opening:

a) 26 in. (660 mm) in the longitudinal direction. The clear opening shall extend from one roof transverse structural member to the next roof transverse structural member.
b) 24 in. (61 cm) in the lateral direction.

3.4.5 Secondary obstruction

The ceiling space below each roof soft spot or roof access hatch shall be free from the following:

a) Wire, cabling, conduit and piping
b) Rigid secondary structure (e.g., duct walls, diffusers, diffuser supports, lighting back fixtures, mounted PA equipment, luggage racks)

Interior panels and liners below each roof soft spot shall be designed such that, after making the cutout through the roof soft spot, it shall be possible to cut an equally sized clear opening through the interior panels and liners using the same tools that were used to cut the soft spot.

4. Analysis

4.1 General

The Manufacturer shall perform structural analysis of the carbody structure and of supports for equipment weighing over 150 lbf (667 N), as defined in Section 2 of this standard. By agreement, the equipment Purchaser may review and approve reports of the structural analysis as a condition for acceptance of the cars. Format and content of the structural analysis reports should be as agreed to by the Purchaser and Manufacturer. The Manufacturer and Purchaser shall agree on an analysis plan prior to performing the analysis.

4.2 Structural representation

In order to define the carbody structure, a structural representation is required. The purpose of the structural representation is to define the primary carbody structure in advance of formal stress analysis and structural drawings.

If presented in 2-D, the structural representation should include a side view, a top view showing one longitudinal half of the roof and one longitudinal half of the underframe, and typical carbody cross-sections.

The 2-D representation should also include cross-sections of the structural members, showing their shape, dimensions, material and thickness.

A 3-D representation should be issued in a format that will allow review and dimensional extraction with the use of commonly available 3-D viewers. Whether presented in 2-D or 3-D, material identification shall be provided, along with a preliminary description of anticipated connections.

The members shown should include, to the extent used in the particular design, typical side frame and door frame posts; end, side, draft and center sills; belt, top and roof rails; collision and corner posts; bolsters, floor beams and cross-bearers; roof carlines and purlins; roof sheathing or corrugation; side frame sheathing and/or corrugation, jacking pads; and locations of energy-absorbing mechanisms where applicable.

4.3 Elastic and elastic-plastic stress analysis

Linear elastic load cases shall be subject to stress analysis consisting of a linear-elastic finite element analysis (FEA) supplemented as necessary by manual analyses. The FEA shall use a recognized code that is readily available and widely used in North America for railcar structural analysis.

For all linear-elastic load cases, the elastic stability of plates, webs and flanges shall be calculated for members subject to compression and/or shear as agreed upon by the Purchaser and Manufacturer.

Severe deformation load cases shall be carried out using non-linear, large-deformation stress analysis consisting of an FEA. The analysis shall account for nonlinear material behavior above the material's elastic limit. The FEA shall use a recognized code that is readily available and widely used in North America for railcar structural analysis.

Manual analysis shall be performed to examine details of the carbody structure (i.e., weld connections, welded and/or bolted joints, buckling and fatigue conditions) that are not readily handled in the FEA.

4.4 Stress analysis report

Analysis report(s) shall be created to demonstrate compliance with the analysis requirements of this standard. The format and content of the report(s) shall be as agreed to by the Purchaser and Manufacturer, but shall contain the following at a minimum:

1. General information about the analyzed item(s), including:
    a) description of each item and the item's intended function;
    b) load case(s) documented in the report;
    c) diagram showing key dimensions, identifying relevant structural member(s), and showing the load application and reaction location(s); and
    d) drawing references.

2. Details about the materials used in the analyzed item(s), including:
    a) diagram showing the locations of each material used; and
    b) mechanical properties and their sources for all materials used, including, at a minimum, tensile modulus, shear modulus, yield strength/proof strength, and ultimate tensile strength.
3. Description of the acceptance criteria for each analysis performed, including:
    a) allowable stresses and/or strains and the means for deriving these values; and
    b) reference to the applicable requirements of this standard.
4. Description of finite element analyses performed, including:
    a) identification of the solver used and type of analysis performed;
    b) diagram showing the applied forces and other boundary conditions for each loading condition;
    c) modeling methods used for load application;
    d) assumptions of how joint behavior is represented (e.g., rivets, bolts, welds)
    e) description of the mesh, including element types, quantity of elements, characteristic element sizes, locations of mesh refinement, and meshing accuracy index; and
    f) important differences between the model and the actual structure.
5. Analysis results using appropriate views and scales, including:
    a) reaction forces and moments;
    b) deflection in three orthogonal axes;
    c) contour plots of von Mises or other approved combination stress;
    d) where agreed to by the Purchaser and Manufacturer, minimum and maximum principal stresses and their directions;
    e) detailed results at locations of highest stress and other critical areas;
    f) identification of structural components with margins of safety less than a threshold agreed to by the Purchaser and Manufacturer, at a minimum 0.2; and
    g) identification of any locations at which allowable stresses are exceeded and an explanation of whether such exceedances are acceptable.
6. Supporting hand calculations or other supplemental analyses, such as buckling, joint strength, or fatigue analysis, with sufficient detail to explain the methodology employed and complete results.
7. Conclusion presenting whether the identified acceptance criteria were met.
8. For large-deformation analyses, the report shall include the nonlinear stress/strain curve and other material properties, such as damping, used in the analysis. Allowable plastic equivalent strain values shall be identified for each material. In addition to identifying the solver and type of analysis, the time step used for the analysis shall be provided. Analysis results shall show, at a minimum, plots of reaction forces and moments over time, deflection in all three axes, energy parameters, and plastic equivalent strain values. The results shall demonstrate that the support structure of the plastically deforming components remains stable under the prescribed conditions.

4.5 Model validation

It is anticipated that compliance with load cases required to achieve compliance with federal regulations, industry standards and the technical specification will not all be demonstrated through physical testing and that modeling results alone will be used to satisfy some of these requirements.

Therefore, it is critical that adequate documentation be provided to establish credibility in the modeling methodology and the ability of the model to produce realistic results.

A model validation report that fulfills this purpose is to be provided. The format and content of the report shall be as agreed to by the Purchaser and Manufacturer, but shall contain the following at a minimum:

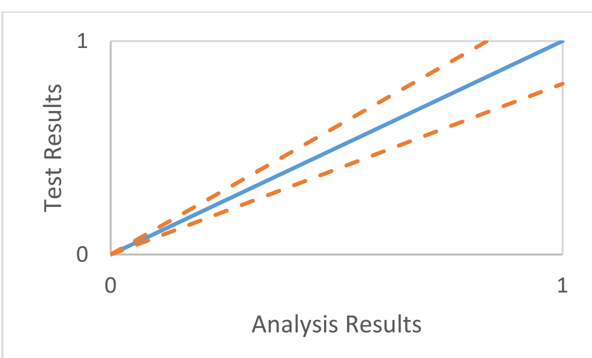
- Identification of which tests will be used for model validation. At a minimum, the static end compression test results (strains and deflections/displacements) shall be included in the model validation activity.
- Identification of which measurement device (strain gauges, displacement sensors, load cells, etc.) output will be used for model validation (if not all). It is recommended that strain gauge measurements that indicate stresses greater than or equal to 25 percent of the allowable be considered in the validation activity. The Manufacturer shall provide an explanation of the rationale for excluding any measurements from the validation activity.
- Identification of the version of the model used to perform the validation activities.
- Appropriate tabulations or other graphical depictions of the comparisons of the model and test results for each of the relevant load cases and for each of the relevant measurement devices and documentation of the relative differences between the two results.
- Explanation of reason(s) for instances in which model results do not correlate with the measured value using the prescribed criteria.

For the purposes of the validation report, the following maximum correlation criteria shall be applied. More restrictive values can be used if agreed to by the Purchaser and Manufacturer:

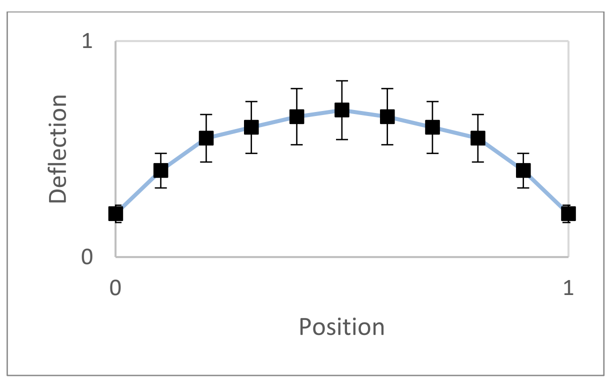
- Model-predicted values of strains/stresses shall be within ±20 percent of the measured values at the relevant locations.
- Model-predicted values of deflections/displacements shall be within ±10 percent of the measured values at the relevant locations.
- Model-predicted load reactions shall be within 5 percent of the measured values at the relevant locations.

Correlation between measured and predicted values shall be presented in a form similar to that shown in **Figure 8**, in which the dashed curves or the error bars represent the correlation tolerance and the solid curves represent the test result. Data for the model-predicted values are added to these plots. Quantities represented by the horizontal and vertical axes are selected based on the relevant load case. Depending on the quantities compared, alternate representations are allowed based on agreement between the Purchaser and the Manufacturer.

FIGURE 8
Format for Correlations Between Measured and Predicted Values



Typical depiction of comparison between test and analysis results for stresses or strains.



Typical depiction of comparison between test and analysis results for deflections/displacements.

In the event that validation cannot be achieved within the correlation tolerances, and model refinement or revision is required for any reason to improve correlation, results for all load cases must be reproduced using the revised model unless the Manufacturer can provide a documented, compelling case describing why this is not necessary.

5. Tests

5.1 General

Testing of the carbody structure, as required by Section 2, shall be performed in accordance with the requirements of this section. When a complete carbody structure is used for testing, the carbody shall be structurally complete, but excluding such items as exterior and interior trim, windows, doors, seats, lights, insulation, interior lining, or any other materials that will obscure any structural member of the car from view. Flooring shall be included in the tests if it is part of the load-carrying structure. All components included in the tests shall be included in the analysis of the test load cases. Underfloor apparatus may be installed, or equivalent weights distributed at their respective locations.

When a separate end frame section is used for testing, the test element shall simulate to the maximum extent possible the location, the degree of fixity, and the magnitude and direction of reactions of the supporting carbody structure.

The test carbody shall be completely inspected and any nonconformances corrected and documented prior to testing. The carbody shall be weighed, and the weight recorded prior to installation of any test equipment.

All gauges and instruments used as part of the test shall be in current calibration and remain so for the duration of the test. The methods of calibration and time periods for recalibration shall be in accordance with a certified standard.

For any design for a carbody that is based on a qualified vehicle, the Manufacturer may provide data from previous tests to satisfy the corresponding portion of these requirements, as approved by the Purchaser. The differences between the qualified vehicle and the new design and the effect of those changes on the carbody structure shall be defined by the Manufacturer.

5.1.1 Test procedure

A test procedure shall be developed prior to conducting any test. The test procedure should include, but should not necessarily be limited to, drawings, sketches, tables, and other descriptions that provide the following:

a) The purpose of the test.
b) A description of the load application equipment and test fixture.
c) The location and type of each load applicator and point of fixation (boundary conditions).
d) A table showing the load applied at each load applicator for each test increment.
e) A table showing the parameters that should be recorded for each test increment.
f) A table showing the pass/fail criteria for each test.
g) The location of each load, strain and deflection-measuring device.
h) Requirements for monitoring stress (or strain) output during the test.
i) A list of conditions under which the test will be terminated, including maximum allowable strains or displacements.

The following items shall be agreed upon by the Purchaser and Manufacturer and listed in the test procedure:

a) Loading the carbody prior to the witness test.

5.1.2 Test report

The Manufacturer shall develop a test report that describes test results and presents supporting data as agreed to by the Purchaser and Manufacturer. Test report shall contain the following, as a minimum:

a) Tables showing stresses and deflections.
b) Description and explanation of any value that exceeded the test criteria.
c) Appendixes containing all data, i.e., output from each gauge for each load step. These data shall be clearly identified and include the date that they were recorded.
d) Stress (or strain) vs. load curves for any gauges that reach more than 80 percent of the allowable stress (or strain) at the maximum load. If no gauges reach this value, then the 10 greatest tension stress locations and the 10 greatest compressive stress locations shall be provided for each test series.
e) A table showing each applied load and reaction load.
f) If the carbody is loaded prior to the witness test, it shall be noted in the test report.

5.2 Compression load tests

5.2.1 Test description

The ability of the carbody structure to resist the compression loads specified in Section 2.1 shall be tested. During the compression test, the carbody shall be supported on trucks, or a simulation thereof, to allow longitudinal movement. For multi-section articulated units, each unique carbody section shall be tested separately. Reactions shall simulate the attachment of the articulation joints. If both ends of the tested section have articulation joints, then both the applied load and reaction configuration shall simulate the attachment of the articulation joints.

The carbody shall be loaded with sufficient dead weight to bring the total body weight up to that of an empty, ready-to-run vehicle. This loading shall be distributed in proportion to the distribution of weight in the finished vehicle.

The coupler compression load shall be applied to the rear buff stop for equipment with conventional couplers or to the coupler support for equipment with pushback couplers, centered along the line of draft. The end sill compression load shall be applied to the end beam or anti-climber using cushioning means to ensure uniform bearing. The test loads shall be applied horizontally along the car’s longitudinal centerline; no allowance shall be made for the camber of the carbody. The test loads shall be applied by means of a controlled hydraulic ram and the force measured by a means independent of those producing the force. The ram may be supported at the car end but shall remain free to rotate at its contact with the car end.

The test load shall be applied in increments of 25, 50, 75, 87.5 and 100 percent of full load. After each load increment is applied, the load shall be reduced to not more than 2 percent of full load. Strain, deflection and load readings shall be taken at each load increment and at each relaxation of load.

5.2.2 Test criteria

The carbody shall comply with the compression test requirements if all of the following criteria are met:

a) There shall be no visual permanent deformation, fractures, cracks or separations in the vehicle structure. Broken welds shall be inspected to determine if the failure is the result of inadequate weld quality or overstress.

b) The maximum stresses calculated from the strain reading in any structural element do not exceed the corresponding allowable stresses as specified in Section 2.1.
c) Indicated residual strains at strain gauges on principal structural elements following removal of the maximum load do not exceed 5 percent of the yield strength divided by the elastic modulus of the material to which the strain gauge is attached. Higher residual strains may be permitted based upon further investigation (e.g., consideration of instrumentation error and boundary condition variations).
d) Test results agree with the structural analysis results within the acceptance criteria specified in Section 4.5. If the structural analysis results do not agree with the test results within the acceptance criteria, then the analysis shall be revised until agreement of the results is within the acceptance criteria.

It is recommended that highly localized yielding or elastic buckling that does not otherwise compromise the ability of the affected structure to meet the requirements of this standard and of the corresponding contract technical requirements be permitted on a case-by-case basis as agreed by the Manufacturer and Purchaser.

5.3 Collision post and corner post tests

5.3.1 Elastic test description

The ability of the collision post, corner post and associated supporting structures to resist the elastic portion of the design loads as listed in **Table 1** shall be tested.

TABLE 1
Elastic Design Loads

Test Article	Section Reference	Load Direction and Sense
Cab-end collision posts	2.3.1.3.1 (b)	Longitudinal inward[1]
Alternative requirements for cab-end collision posts	2.3.1.3.2	Longitudinal inward[1] (where feasible)
Coach car collision posts	2.3.1.4 (b)	Longitudinal inward[1]
Collision posts, permanently and semi-permanently coupled articulated cars	2.3.1.5	Longitudinal inward[1] (depending on vehicle configuration)
Cab-end corner posts	2.3.2.3.1 (b)	Worse case of longitudinal and lateral inward
Cab-end, non-operator side corner posts, alternate requirements	2.3.2.3.3.1 2.3.2.3.3.2 (b) & (f) 2.3.2.3.3.3 (b) & (e)	Worse case of longitudinal and lateral inward for each post
Alternative requirements for cab-end corner posts	2.3.2.3.4	Worse case of longitudinal and lateral inward
Coach car corner posts	2.3.2.4 (b)	Longitudinal inward[1]

1. Test load 15 deg. from longitudinal is permitted as an alternate if agreed to between Purchaser and Manufacturer.

The test loads shall be applied to a structurally complete carbody, or as an alternative, a separate end frame section may be constructed and tested.

The force of the testing machine shall be measured by a load cell or equivalent device independent of the equipment producing the applied force. Cushioning means shall be provided to ensure uniform bearing. The means of cushioning should not be attached to the post. For testing collision posts, the load application area should not exceed a height of 6 in. (152 mm) by the width of the post, up to a maximum of 36 in. (914 mm). For testing corner posts, the load application area should not exceed 10 in. (254 mm) by 10 in. (254 mm).

The test load shall be applied in increments of 50, 75 and 100 percent of full load. The load shall be reduced to not more than 2 percent of full load after each step. Strain gauge and deflection readings shall be taken at each load increment and at each relaxation of load. The ram shall be supported at the car end but shall remain free to move longitudinally with respect to the car end.

5.3.2 Elastic test criteria

The collision and corner posts shall comply with the elastic test requirements if all of the following criteria are met:

a) There shall be no visual permanent deformation, fractures, cracks or separations in the vehicle structure. Broken welds shall be inspected to determine if the failure is the result of inadequate weld quality or overstress.
b) The maximum stresses calculated from the strain reading in any structural element do not exceed the corresponding allowable stresses as specified in Section 2.3.
c) Indicated residual strains at strain gauges on principal structural elements following removal of the maximum load do not exceed 5 percent of the yield strength divided by the elastic modulus of the material to which the strain gauge is attached. Higher residual strains may be permitted based upon further investigation (e.g., consideration of instrumentation error and boundary condition variations).
d) Test results agree with the structural analysis results within the acceptance criteria specified in Section 4.5. If the structural analysis results do not agree with the test results within the acceptance criteria, then the analysis shall be revised until agreement of the results is within the acceptance criteria.

It is recommended that highly localized yielding or elastic buckling that does not otherwise compromise the ability of the affected structure to meet the requirements of this standard and of the corresponding contract technical requirements be permitted on a case-by-case basis as agreed by the Manufacturer and Purchaser.

5.3.3 Elastic–plastic test description

The ability of the collision post and associated supporting structures to resist the elastic/plastic design loads specified in Section 2.3 shall be tested.

The placement of the applied load shall be 30 in. in height from top of the underframe in longitudinal direction of the carbody.

It is recommended that the test loads be applied to a special test article consisting of an end frame and sufficient carbody structure to provide a representative support condition. The test article shall be supported in such a fashion as to allow the load path to be fully developed, as would occur in a complete car with the load reacted at the opposite end of the car.

The force of the testing machine shall be measured by a load cell or equivalent device independent of the equipment producing the applied force. Cushioning means shall be provided to ensure uniform bearing. The means of cushioning should not be attached to the post. For testing collision posts, the load application area should not exceed a height of 6 in. (152 mm) by the width of the post, up to a maximum of 36 in. (914 mm). For testing corner posts, the load application area should not exceed 10 in. (254 mm) by 10 in. (254 mm).

The initial load, within the elastic limit of the post, shall be applied in increments of the same magnitude as described in Section 5.3.1 for elastic tests. The load shall be reduced to not more than 2 percent of full load after each step. Strain gauge and deflection readings shall be taken at each load increment and at each relaxation of load. This portion of the elastic–plastic test may be used to satisfy the requirements of Section 5.3.1. After the full elastic limit load has been attained, additional load shall be applied until the energy absorption requirement is met. All load cells, strain gauges and deflection gauges shall be recorded continuously.

The ultimate load carrying capacity of the post shall be defined as the condition where the post cannot support an increased load or the center of the post has deflected more than its full depth. This deflection shall be measured at the point of greatest deflection experienced on the post with reference to a nonmoving datum on the test article.

5.3.4 Elastic–plastic test criteria

The collision and corner posts shall comply with the elastic–plastic test requirements if the connections between the posts and the supporting structural members are not completely separated and the post deflection into the cab or passenger compartment is not in excess of 10 in. (254 mm) prior to meeting the minimum energy absorption requirements of Section 2.3.

5.4 Other structural testing

Other structural tests to be carried out shall be agreed upon between the Purchaser and Manufacturer. These could include the following:

a) Vertical load test in accordance with Section 3.1.
b) Torsion (diagonal jacking) test in accordance with Section 3.3.
c) Fatigue test of connection components including spot welds.
d) Testing of non-service-proven arrangements and connections.

Related APTA standards

APTA-PR-CS-S-004-98, "Austenitic Stainless Steel for Railroad Passenger Equipment"
APTA-PR-CS-S-006-98, "Attachment Strength of Interior Fittings for Passenger Railroad Equipment"
APTA-PR-CS-S-011-99, "Cab Crew Seating Design and Performance"
APTA-PR-CS-S-015-99, "Aluminum and Aluminum Alloys for Passenger Equipment Carbody Construction"
APTA-PR-CS-S-016-99 Rev. 2, "Row-to-Row Seating in Commuter Railcars"
APTA-PR-CS-RP-019-12, "Pushback Couplers in Passenger Rail Equipment"
APTA-PR-M-RP-003-98, "Purchase and Acceptance of Type H Tightlock Couplers"
APTA-PR-M-S-016-06, "Safety Appliances for Rail Passenger Cars"
APTA-PR-PS-S-006-23, "Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment"

References

This standard shall be used in conjunction with the following publications. When the following standards are superseded by an approved revision the revision shall apply.

49 CFR, Part 238, Passenger Equipment Safety Standards, Subpart C, Specific Requirement for Tier I Passenger Equipment

Association of American Railroads standards:
- AAR S-034, Specification for the Construction of New Passenger Equipment Cars (obsolete, available from APTA)
- AAR S-580, Locomotive Crashworthiness Requirements

ASTM International standards:
- ASTM A6, Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
- ASTM A568, Standard Specification for Steel, Sheet, Carbon and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for
- ASTM A572, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
- ASTM A588, Standard Specification for High-Strength Low-Alloy Structural Steel, up to 50 ksi [345 MPa] Minimum Yield Point, with Atmospheric Corrosion Resistance
- ASTM A606, Standard Specification for Steel, Sheet and Strip, High Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, with Improved Atmospheric Corrosion Resistance
- ASTM A710, Standard Specification for Precipitation–Strengthened Low-Carbon Nickel-Copper-Chromium-Molybdenum-Columbium Alloy Structural Steel Plates
- ASTM A749, Standard Specification for Steel, Strip, Carbon and High-Strength, Low-Alloy, Hot-Rolled, General Requirements for
- ASTM A1011, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
- ASTM A1066, Standard Specification for High-Strength Low-Alloy Structural Steel Plate Produced by Thermo-Mechanical Controlled Process (TMCP)

American Welding Society standards:
- AWS D1.1, Structural Welding Code, Steel
- AWS D1.2, Structural Welding Code, Aluminum
- AWS D1.3, Structural Welding Code, Sheet Steel
- AWS D1.6, Structural Welding Code, Stainless Steel

AWS D15.1, Railroad Welding Specification – Cars and Locomotives

SAE International standards:
SAE J429, Mechanical and Material Requirements for Externally Threaded Fasteners
SAE J995, Mechanical and Material Requirements for Steel Nuts

Definitions

articulated: An arrangement of rail rolling stock where adjacent units share a common truck at their interface.

belt rail: A continuous or effectively continuous longitudinal framing member or longeron in the side frame at approximately mid-height. In side frames with normal passenger side window openings, the belt rail is typically immediately below the windows, where it also serves as part of the framing for the window openings.

body corner posts: Cab cars and MU locomotives using low-level passenger boarding on the non-operating side of the cab may have two full-height corner posts on that side, one post located ahead of the stepwell (the "corner post") and one located behind it (the "body corner post").

carline: Transverse, structural, roof framing member used to support the roof sheets.

flat-end MU car/cab car: A vehicle with an end similar to that of a typical coach, such that the corner and collision posts are essentially vertical for their full height and in the same transverse plane, except as required for curving clearance.

load factor: Load factor is defined as a number by which the actual or specified load is multiplied in computing the design load. The load factor shall include all applicable safety factors.

margin of safety: The margin of safety (MS) is defined as follows:

$$MS = [(Allowable\ Stress)/(Applied\ Stress)] - 1$$

The calculated stress shall include the applicable load factors. The allowable stress may be the ultimate stress, yield stress, critical stability stress, or fatigue stress.

MU car: An electric multiple unit (EMU), with or without traction motors, or a diesel multiple unit (DMU). See also definition for MU Locomotive in 49 CFR 238.5.

passenger car: Refer to definition provided in 49 CFR 238.5.

passenger equipment: Refer to definition provided in 49 CFR 238.5.

non-passenger-carrying locomotive: A locomotive not intended to provide transportation for a member of the general public but used to power a passenger train.

permanent deformation: A member shall be permanently deformed if:

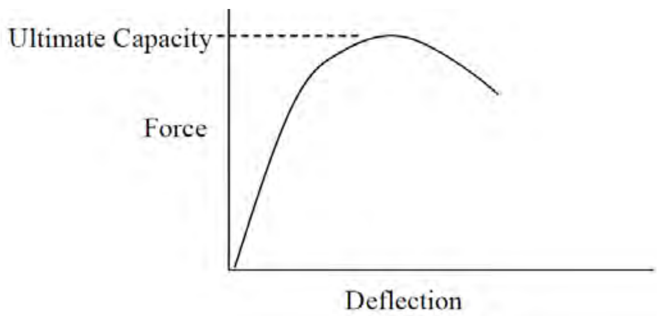
1. the material supplier's guaranteed minimum yield strength, or other minimum yield strength agreed to by the Purchaser and Manufacturer, has been reached or exceeded (for material for which the supplier only publishes a yield strength, the supplier's guaranteed minimum shall be used); or
2. the material has deformed and will not return to its original shape after the load is released.

roof access hatch: Built-in access opening of suitable size, covered by a hatch, which is mechanically locked or latched into place in a watertight manner.

roof soft spot: Designed and identified area of the roof where heavy structure does not impede the cutting-out of access holes of suitable size with tools that are routinely carried on fire department emergency response vehicles.

side sill: The outside longitudinal member of the underframe.

ultimate capacity: maximum peak force resisted by the structural member as illustrated in the figure below.



Abbreviations and acronyms

AAR	Association of American Railroads
AISC	American Institute of Steel Construction
ASTM	ASTM International (formerly the American Society for Testing and Materials)
A-T	anti-telescoping (plate)
AWS	American Welding Society
AW0	empty car, ready to run weight
CEM	crash energy management
CFR	Code of Federal Regulations
CG	center of gravity
CGHAZ	coarse grain heat-affected zone
CWB	Canadian Welding Bureau
DMU	diesel multiple unit
EMU	electric multiple unit
FEA	finite element analysis
FRA	Federal Railroad Administration
FRP	fiber reinforced polymer
ft-lb	foot pound-force
HSLA	high-strength low-alloy steel (low alloy high tensile)
J	joules
kN	kilonewton
ksi	kilopound force per square inch
LAHT	low alloy high tensile (high-strength low-alloy steel)
lbf	pound-force
MJ	megajoule
MS	margin of safety
MU	multiple unit
MPa	megapascal
NATSA	North American Transportation Services Association

PA	public address
psi	pound-force per square inch
RMS	Railway Mail Service specification

Summary of document changes

- Document formatted to the new APTA standard format.
- Sections have been moved and renumbered to accommodate the new format.
- Scope and summary moved to the front page.
- Definitions, abbreviations and acronyms moved to the rear of the document.
- Two new sections added: “Summary of document changes” and “Document history.”
- Some global changes to section headings and numberings resulted when sections dealing with references and acronyms were moved to the end of the document, along with other cosmetic changes, such as capitalization, punctuation, spelling, grammar and general flow of text.
- Scope and purpose section was revised to address removal of CEM related requirements from this standard.
- CEM related requirements have been removed from this standard and it will be published in the in-progress APTA PR-CS-S-035. Requirements for passenger equipment with pushback couplers have been retained in this standard.
- Non-passenger carrying locomotive requirements were retained throughout the document based on working group recommendations.
- Several sections were added to clarify and elaborate on alternative requirements per 49 CFR 238 Appendix F.
- Section 1.2 was revised to add additional materials that are frequently used in the manufacture of passenger equipment.
- Section 2.1.2 requirements for passenger equipment with pushback couplers were modified to harmonize changes to APTA PR-CS-RP-019 and also remove inconsistency with 49 CFR 238.203.
- Section 2.1.3 was modified to provide clarity in terms of types of analysis required as well as potential allowance for highly localized yielding or elastic buckling.
- Section 2.2.2.2.1 Clarified that analysis is sufficient to demonstrate rollover strength.
- Section 2.2.2.2.2 Updated requirements to apply to a wider range of carbody constructions, including multi-level vehicles.
- Section 2.3 Clarified that all connections of collision posts and corner posts to the carbody supporting structure must be designed to resist failure during plastic bending of the post.
- Section 2.3.1.2.1 Removed vertical downward loading requirement for non-passenger carrying locomotive collision post connections because the working group does not believe that this requirement leads to improved connection strength for the collision posts.
- Section 2.3.1.3.1 Made several clarifications in terms of load application points as well as added specificity towards energy absorption portions.
- Section 2.3.1.3.2 Added alternative requirements per 49 CFR 238 Appendix F. The quasi-static elastic-plastic testing of the front-end structure is mandatory.
- Section 2.3.1.5 Added reference to applicable CFR requirement.
- Section 2.3.2.3.1 Made several clarifications to load application points, distribution of load, and the use of AWS and CWB as appropriate welding codes.
- Section 2.3.2.3.3 Made elastic testing mandatory for the requirements at 18 inches only which is consistent with section 2.3.2.3.1.
- Section 2.3.3 Clarified that analysis is sufficient to demonstrate the strength requirements for the structural shelf. Testing is optional.
- Section 2.3.4 Updated text for clarification. Added prohibition against using an FRP mask alone to meet the fluid entry inhibition requirement.

- Section 2.4.2 Clarified that the weight of the trucks is included in the rollover load case.
- Section 2.4.3 Changed the concentrated loads to distributed loads over a 5"x5" area.
- Section 2.5.1 Removed requirement to apply climb, bypass, and overturn loads in combination with "high compression" loads.
- Section 2.5.2.1 Added articulation joints as an acceptable means of climb resistance. Added anti-climbing requirements for vehicles with push-back couplers.
- Section 2.6.1 Clarified that structural analysis is sufficient to demonstrate compliance with the truck-to-carbody attachment requirements. Clarified that 250,000 lbf. force is applied at the height of the truck's center of gravity.
- Section 2.8 Added climb, bypass, and overturn loads to the list of emergency load cases.
- Section 3.0 New section added for design loads and practices. Requirements include: Carbody Vertical Load, Carbody Fatigue Analysis, Carbody Torsional Loads, and Roof Emergency Access.
- Section 4.5 Added requirements for validating finite element models using test results.
- Section 5.1.1 Added test procedure section.
- Section 5.1.2 Added test report section.
- Section 5.2.1 Added requirements for end compression testing of articulated units. Updated load application and measurement requirements for compression tests.
- Section 5.2.2 Added requirements for correlation between test and analysis results.
- Section 5.3.1 Updated load distribution (cushioning) device requirements. Added test load increment requirements.
- Section 5.3.3. Clarified load application location and direction. Added requirements for using end frame assemblies for testing.
- Table 1 was updated to add sub-section numbers referred to for the exact testing requirements. This was considered a typographical change given that this information used to exist in Revision 2 and was inadvertently omitted in Revision 3.
- Revision 3.1: Table 1 was updated to add sub-section numbers referred to for the exact testing requirements. This was considered a typographical change given that this information used to exist in Revision 2 and was inadvertently omitted in Revision 3.
- Revision 3.2: Several minor clarifications were provided due to member requests.
- Revision 3.3: Update of roof access marking references to APTA-PR-PS-S-006-23, "Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment."

Document history

Document Version	Working Group Vote	Public Comment/ Technical Oversight	Rail CEO Approval	Policy & Planning Approval	Publish Date
First published	—	—	—	Oct, 14, 1999	Jan, 11, 2000
First revision	—	—	—	May 22, 2003	Sept, 28, 2003
Second revision	—	—	—	April 10, 2006	June 15, 2006
Third revision	August 15, 2019	Dec. 3, 2019	May 18, 2020	June 12, 2020	June 18, 2020
Revision 3.1	August 15, 2019	Dec. 3, 2019	May 18, 2020	June 12, 2020	Oct 7, 2021
Revision 3.2	August 15, 2019	Dec. 3, 2019	May 18, 2020	June 12, 2020	June 15, 2022
Revision 3.3	August 15, 2019	Dec. 3, 2019	May 18, 2020	June 12, 2020	July 26, 2023

Appendix A (informative)

A.1 Purpose

This annex traces the history behind some of the structural design requirements contained in the body of APTA PR-CS-S-034-99.

A.2 APTA structural design and construction requirements

APTA PR-CS-S-034-99 is largely based on AAR Standard S-034. A calamitous train wreck in Tortuga, California, in 1938 was the specific reason for the preparation and issuance of AAR S-034 in 1939, based on the Railway Mail Service Specification then in effect. One of the horrific results of the wreck was the telescoping of a car of lightweight design by the heavyweight car to which it was coupled, resulting in heavy casualties in the lightweight car. From descriptions of the analysis of the wreck, it is clear that it was thought that the telescoping was much the worse because of inadequate resistance to climbing forces at the coupled interface between the lightweight and heavyweight cars (inadequate anticlimbing provisions), and because of inadequate provisions for attachment of the trucks to the carbody (see discussion in Section A.2.6).

AAR S-034 was the standard for passenger car design for many decades and, although discontinued by the AAR in 1989, still serves as a reference source for passenger car design now and probably well into the future. APTA PR-CS-S-034-99, when initially published in January 2000, was based upon the then-obsolete AAR S-034 and on similar FRA requirements introduced in April 1959 in 49 CFR 229.141. The intent of the Construction and Structural Subgroup of the APTA PRESS Task Force in initially preparing this standard was to document and improve upon the then-current practice. The requirements of this standard in many areas exceeded those of AAR S-034 and 49 CFR 229.

AAR S-034 was an industry consensus standard and contained emergency load requirements, as well as normal load requirements and other requirements intended to standardize designs to facilitate interchange of equipment among member railroads. Although the initial release of APTA PR-CS-S-034-99 contained primarily emergency load requirements, it was expected that over time the standard would be expanded to fill a similar role as AAR S-034, covering normal load requirements and standardization issues in addition to crashworthiness requirements.

Subsequent revisions of APTA-PR-CS-S-034-99 included requirements for carbody designs using crash energy management (CEM) and structural requirements for non-passenger-carrying locomotives. The CEM requirements were removed from the latest revision of this standard because they will be included in the future standard APTA PR-CS-S-035, currently under development by the Construction and Structural committee. Requirements for passenger equipment with pushback couplers have been retained in this standard.

The following sections provide historical details regarding the specific design loads in this standard.

A.2.1 Anti-climbing

To respond to the inadequacies in climbing resistance observed in the 1938 Tortuga wreck, requirements for an "anticlimbing arrangement" were included in AAR S-034. The AAR standard (a recommended practice when first issued) permitted the use of standard tightlock couplers to meet the requirement. Other requirements imparted a yield strength of 100,000 lbf (445 kN) under the action of vertical forces transmitted between coupled units. The typical design solution has been tightlock couplers that remain locked together even when subjected to vertical forces or displacements, built into the end of the car in a manner that permits vertical forces (up and down) as high as 100,000 lbf (445 kN) to be transmitted from car to car via the coupler without yield of any structure. The AAR requirement was stated in general terms—it was a performance requirement—and other design solutions are certainly possible in response to a requirement for an "anti-climbing arrangement." But the use of a tightlock coupler built in to the end of the car to transmit the required vertical forces has been the nearly universal solution for cars, including MU and cab cars.

Because of the genesis of the AAR anticlimbing requirement for cars, the telescoping in the 1938 Tortuga wreck, it is clear that for cars, the intent and meaning of anticlimbing has been resistance to override (and then telescoping) between coupled units. For car designers, manufacturers and operators, that understanding continues to this day and is the basis for the requirement in this APTA standard.

When first issued, FRA anticlimbing requirements at 49 CFR 238.205(b) were based on the locomotive concept of a separate shelf-like device on the end of the unit above the coupler. The industry responded with designs that employed the traditional solution for cars of a tightlock coupler built into the end of the car with a buffer beam above and coupler carrier below with strength increased to 200,000 lbf (890 kN) at ultimate instead of 100,000 lbf (445 kN) at yield. The FRA persisted in requiring a locomotive style anti-climber. However, the industry was not able to develop a design solution for that style of anti-climber for a MU or cab car that was compatible with a cab design having a trainline door, threshold, and walkover plate, to preserve the option of operating the cab car in consist. FRA solved the problem for the industry by its letter of Nov. 27, 2001, excepting cab and MU cars from the anti-climbing requirements of 49 CFR 238.205(b), and allowing the traditional solution of using tightlock couplers to provide climb resistance. This change was later incorporated into 49 CFR 238.205(a) and (b) in January 2010 and is reflected in this standard.

This APTA standard considers not only vertical (override) forces, but also lateral (bypassing) and torsional (overturning) loads that might be developed between units in collisions and derailments. This standard clarifies that the strength of the coupler carrier and buffer beam constructions are an integral part of the anticlimbing arrangement in cases where a drawbar or a standard APTA (AAR) tightlock coupler or equivalent is used.

A.2.2 End-frame anti-telescoping structure

Regarding carbody end frame anti-telescoping structure, this standard was originally based on the requirements in AAR S-034 and 49 CFR 229.141 for "main vertical members" in the end frame, updated to include the higher strength levels of design practice at the time this standard was originally issued, requirements for compatible strength of the post supporting structure and intervening connections, and other aspects of that earlier design practice. These requirements have been updated in the latest revision of this standard to ensure conformance with the current minimum requirements from FRA in 49 CFR 238. The requirements provided by FRA are in some cases exceeded by this standard.

A.2.3 Corner posts

This APTA standard contains specific requirements for corner posts that were not originally included in AAR S-034 or in 49 CFR 229. Passenger cars have for many decades included substantial structural posts at the body corners, the extreme corners if an end-vestibule design, or both. Designs often met the minimum section modulus requirements of AAR S-034 for end-frame "main vertical members" by distributing some of the required section properties to corner posts ("traditional" design practice).

The initial release of this standard included corner post requirements for non-passenger-carrying locomotives because there had never been a regulation or traditional industry practice that mandated or specified the use of corner posts for non-passenger-carrying locomotives. However, similar requirements for corner posts on non-passenger-carrying locomotives have since been incorporated into AAR S-580 and 49 CFR 229, so they have been removed from the latest revision of this standard.

The corner post requirements in this APTA standard are based on traditional design practice, updated to include the best of design practice at the time of initial release of this standard, and input from the

Construction and Structural Subgroup and APTA PRESS Task Force members in response to the FRA request for higher-strength corner posts. Although most purchase specifications for commuter cars during the period just prior to the initial release of this standard included requirements for corner posts that greatly surpassed earlier design practice, higher corner post strength requirements for non-passenger-carrying locomotives and cab ends of MU cars and cab cars were priority items for the FRA during the preparation of the initial release of this standard, and so they have been addressed in considerable detail. In Section 2.3.2.3.1 of this standard, requirements for corner posts that are applicable for the cab end of MU cars and cab cars are outlined. These requirements are significantly higher than had been applied to car design prior to the initial release of this standard.

In cases where the new, more stringent requirements of Section 2.3.2.3.1 cannot be achieved on cars that use low-level boarding, optional requirements that are compatible with a low-platform stepwell but that still represent a significant increase in corner post design load requirements are outlined in Section 2.3.2.3.3.

It is recommended that cab-end, non-cab-side corner posts be designed to meet the requirements of Section 2.3.2.3.1 when possible. Implementation of the alternative requirements of Section 2.3.2.3.3 shall be subject to an evaluation performed by the Manufacturer and approved by the Purchaser that demonstrates that the requirements of Section 2.3.2.3.1 are not practical, given the other requirements for the design. This approach is consistent with the latest requirements from FRA in 49 CFR 238.213(c).

A.2.4 Cab-end collision posts and corner posts

Revision 1 of this standard included a recommended practice for severe deformation of posts that required cab-end posts to be designed such that the post would reach its ultimate capacity before the top and bottom connections would fail. Further analysis and testing was required to quantify severe deformation requirements that could be included in an APTA standard. Analysis and testing that has since been conducted by FRA/Volpe and the industry has led to Revision 2 of this standard, which required cab-end collision and corner posts to be designed to absorb a specified amount of energy and to limit the amount of permanent deformation of the posts into the operator's cab or passenger seating area. The standard also defines appropriate pass/fail criteria in an attempt to avoid potential conflicts when trying to demonstrate compliance. These requirements have been carried over to the latest revision of this standard.

Before specifying in the standard an amount of energy that the posts would have to absorb, the industry determined that testing of actual APTA-compliant cab car end frames was needed. The results of these actual quasi-static tests would be used as the basis for the requirements of the standard rather than relying only on the results of finite element modeling. Bombardier Transportation agreed to conduct quasi-static testing of the LIRR M7 cab-end collision post and corner post. The results of these tests indicated that posts could be designed to resist the static loading conditions in this standard and still absorb a significant amount of energy when overloaded. The requirements for the severe deformation of cab-end collision posts and corner posts specified in the standard are based on the results of the M7 tests.

While it was recognized that all the research and testing of cab-end collision posts and corner posts were done for "flat-end" cab cars, this standard also allows the use of the dynamic performance requirements presented in Appendix F to 49 CFR 238 for car designs that are not flat-ended.

A.2.5 End-compression strength

This standard follows the North American precedent for carbody structure to have a minimum of 800,000 lbf (3559 kN) of end-compression strength on the line of draft. However, this standard reinstates a previous practice of permitting a sharing of end-compression strength between the line of draft and the underframe in cases where a pushback coupler, compatible with the intended use of the equipment, is selected for use.

A.2.6 Truck attachment

Truck attachment strength requirements in this standard were also initially based on corresponding requirements in AAR S-034 and 49 CFR 229, but applied these requirements to all passenger equipment. FRA has since added truck-to-carbody attachment requirements to 49 CFR 238.219, but this APTA standard continues to include requirements exceeding those of FRA.

The truck attachment requirements in this APTA standard can be traced back to the same 1938 train wreck in Tortuga, California, that spawned the anti-climbing requirements discussed in Section A.2. Regarding the telescoping discussed in Section A.2, from descriptions of the analysis of the wreck, it is clear that it was thought that the telescoping was much the worse because the truck (or trucks) on the heavyweight car were left behind on the ground due to inadequate attachment to the carbody. This means the additional weight of the trucks was not available to counter a tendency for the car to rise up. Therefore, AAR S-034, when issued, required the trucks to be “locked” to the carbody. This APTA standard includes this requirement, defining “locked” to mean attached with a factor of safety of 2 based on yield of the attaching elements and the weight of the complete truck. In the vertical direction, then, the requirement is related to the weight of the truck, and also addresses safety during maintenance and rerailing operations where the trucks are raised with the car.

There is another potential benefit of the trucks remaining attached to the carbody in an incident like the 1938 Tortuga wreck. Assuming that overriding in such incidents is probably inevitable and that, for whatever reason, the heavyweight overrides the lightweight car (which is what happened in the example wreck), the superstructure of the lightweight car would offer little resistance to telescoping by the battering-ram underframe and superstructure of the heavyweight car. Regardless, then, telescoping to some extent was probably also inevitable during the Tortuga wreck, but if the truck had remained attached with high horizontal strength, once the heavyweight truck struck the end of the underframe of the lightweight car, further telescoping would have been possible only after the attachment strength in the horizontal plane had been overcome. Therefore, a requirement for the truck-to-carbody attachment to have a strength in the horizontal plane (a “shear value”) of 250,000 lbf (1112 kN) was featured as a specific improvement of the AAR standard when issued compared with the RMS on which it was based. This APTA standard includes this requirement along with additional details regarding the conditions under which the requirement must be met. Unlike some international standards that relate truck attachment strength to truck weight, this standard follows the North American concept of setting the horizontal strength of the attachment at the relatively high value of 250,000 lbf (1112 kN) for the purpose of making the truck available as a battering ram for a last-ditch defense against telescoping.

This standard incorporates the practice at the time of its initial release of permitting the vertical and horizontal strength requirements to be considered as separate load cases. This is consistent with the North American concept of retaining the trucks with the car under all conditions except intentional removal, and then taking advantage of there being a semi-permanent appendage of the carbody by also imparting high horizontal strength to the means of retention. The vertical load case is for the purpose of “locking” (as in AAR S-034) the trucks to the carbody, so the benefits of the truck weight and the attachment horizontal shear value are available in collisions and derailments, and for safety while lifting the equipment with the trucks attached for maintenance and rerailing operations. As required by this APTA standard, however, the horizontal load case will have internal forces and moments, including vertical forces, that must be accounted for by the design of the carbody, truck and attaching structural elements.

A.2.7 Side impact

Robert Ebenbach, a railcar structural engineer who started with the Budd Company in the early 1930s, was, later in his career, involved in the repair of railcars damaged by collision, fire, derailment and other accidental damage. There were several cases of sideswiping of stainless steel MU cars in the New York region where the damage to the body structure seemed to him to be extraordinarily severe, even for relatively minor incidents.

He noticed that gussets connecting floor beams and cross-bearers to the side sill buckled in the area of the side sill damaged by the sideswiping. The gussets were, of course, intended to transfer the vertical load from the floor to the side sill and the side frame, and therefore were simple flat plates that were perfectly adequate for that purpose. However, without flanges on their edges, or other stabilizing features, they quickly buckled in a sideswiping incident. Ebenbach devised a static design load to be applied to the side sill to force the designer to stabilize the gussets, so they would not only be effective in transferring vertical load, but also in supporting the side sill in the transverse direction. Then, in a side swiping incident, the gussets would be able to transfer axial load into the floor transverse framing members, so the underframe would be at least partially effective in resisting transverse loads applied to the side sill as a plate-girder structure.

Ebenbach devised a similar design load for the belt rail (the major longitudinal member just below the passenger side windows) to address his observation of unnecessarily severe damage also at that location. In the designs prevalent in the New York region at that time, this was the widest point of the body, and so was almost always subject to damage in side-swiping incidents. The belt rail is intercostal to the side frame posts, and the design load was intended to force the designer to connect the intercostal belt rail sections across the posts so that the rail would act as a continuous member. This greatly increased the resistance of the body structure to side loads at the height of the belt rail.

At the earliest stages of its safety initiative, FRA asked the industry to consider designing rail vehicle structures to resist side impact loads. FRA suggested a scenario that was essentially a loaded highway semi-tractor-trailer driven at relatively high speed into the side of a train. In its deliberations on this subject, the APTA Construction and Structural Subgroup was not able to come to consensus on design requirements that would represent the FRA side-impact scenario. The transverse side sill and belt rail design load concepts devised by Ebenbach were proposed as an alternate, and consensus was achieved.

For the future, the APTA Construction and Structural Subgroup has committed to a more thorough investigation of the feasibility of designing rail vehicles for the FRA side-impact scenario.

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PRESS Mechanical Working Group
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Powered Exterior Side Door System Design for New Passenger Cars

Abstract: This standard contains the minimum requirements for powered exterior side door systems and door system function on new rail passenger cars.

Keywords: doors, door systems, emergency evacuation

Summary: This standard identifies the minimum design requirements for powered exterior side door systems on new intercity and commuter rail passenger cars operating on the general railroad system of transportation. These doors provide entrance and exit for normal passenger boarding and detraining, as well as an emergency egress/access path. This standard sets out requirements and references regarding the design of this type of passenger door system, intended for use in specifications for the procurement of new passenger cars.

Scope and purpose: This standard shall be used in specifications for the procurement of new passenger cars. The requirements outlined herein are for newly manufactured door systems and should not be applied to door systems in use that may have variations in performance due to wear, etc. Passenger compartment doors (end frame and vestibule doors), manually operated doors, galley doors, room access, locker doors, equipment access doors, toilet doors, interior cab access doors, luggage compartment doors and equipment hatches are not covered by this standard. The requirements in this standard supersede all mechanical and non-structural requirements in APTA-PR-CS-S-012-02 that are applicable to powered exterior side doors.

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Introduction

This introduction is not part of APTA PR-M-S-018-10, Rev. 1.1, "Powered Exterior Side Door System Design for New Passenger Cars."

This standard applies to all:

1. Railroads that operate intercity or commuter passenger train service on the general railroad system of transportation; and
2. Railroads that provide commuter or other short-haul rail passenger train service in a metropolitan or suburban area, including public authorities operating passenger train service.

This standard does not apply to:

1. Rapid transit operations in an urban area that are not connected to the general railroad system of transportation;
2. Tourist, scenic, historic, or excursion operations, whether on or off the general railroad system of transportation;
3. Operation of private cars, including business/office cars and circus trains; or
4. Railroads that operate only on track inside an installation that is not part of the general railroad system of transportation.

Powered Exterior Side Door System Design for New Passenger Cars

1. Structure of standard

The design and operation of a powered door involves a complex system. Interfaces occur at individual doors, on a car basis and on a train basis. This standard is organized to address design requirements that occur at these different levels:

- **Section 2** addresses design requirements for individual side door openings.
- **Section 3** addresses system design requirements for an individual car.
- **Section 4** addresses system design requirements for a coupled train.
- **Section 5** addresses overall system safety requirements.

2. Passenger exterior side door design requirements

This section provides design requirements for powered doors at an individual side doorway.

2.1 Door control station

A door control station may be provided in a car with powered doors to control the normal operation of the exterior side doors, other doors on that car, or other cars in the train via trainline control signals.

A crew key or other secure device shall be required to activate a door control station in order to prevent unauthorized use. Removal of the key or device shall deactivate the station.

If the door system is provided with a passenger open door function, the door control station shall be equipped with the device that enables the passenger open door function. The device shall only enable the use of the passenger open door function on the respective side of the car or train when the train is at a standstill and shall not open the doors. The train crew shall have the ability to override and cancel the enable function from an activated door control station.

Door status indicators may be incorporated into the door control station to display the open or closed status of the doors at that doorway or on the car, and/or the status of the door-closed summary circuit. If indicators are provided on the door control station, then a test feature shall be incorporated to provide a method of identifying failed indicators.

2.2 Closed and latched

At the end of the close cycle, a door shall be fully closed and mechanically latched to prevent an unintentional door opening.

Detection shall be provided for each side door panel to indicate when the door is closed and latched. The detection shall be part of the door summary circuit.

2.3 Door manual opening and closing force

When power is removed from the door motor and the door latch is released, door panel friction, including seals and hangers, shall allow the doors to be opened or closed manually with as low a force as practicable.

2.4 Obstruction detection

The door system design shall incorporate a method to detect an obstruction in the path of a closing door. The force exerted on an obstacle required to trigger the detection of an obstruction shall not exceed the following when the door is powered to close:

- Peak force (F_p): 68 lbf
- Effective force (F_e): 45 lbf

Appendix A defines these values and a test procedure that shall be used to measure them in a required test.

When an obstruction is detected, the door system shall react in a manner that will allow the obstruction to be released. A method for detecting an obstruction and preventing the closure of a powered door shall be included as part of the design of the door controls. The doors shall not close and latch to permit a closed-door indication if an obstruction is detected.

2.4.1 Sensitivity

The sensitivity of the obstruction detection system shall be demonstrated as defined by the following test procedure when a door is commanded to close:

- The system shall detect a rigid flat bar, ¼ in. wide and 3 in. high, held between and perpendicular to the door panels or between and perpendicular to the panel and doorframe (for a single panel door opening). This sensitivity shall be required along the length of the panel except in the uppermost 3 in. measured from the top of door opening and in the lowermost 1 in. of the door leading edge measured from the top of the door opening threshold.
- The system shall detect a rigid rod, ⅜ in. in diameter, held between and perpendicular to the door panels or between and perpendicular to the panel and the doorframe (for a single panel door opening) at all locations along the length of the door leading edges, except in the uppermost 3 in. measured from the top of door opening and lowermost 1 in. of the door leading edge measured from the top of the door opening threshold.
- The test specimens for the above requirements shall be of sufficient length to span the door seals.

2.4.2 Pushback

Provisions may be provided to allow a door panel to be manually pushed back to permit an obstruction to be removed.

The force required to push back a door panel shall not exceed 45 lbf.

2.5 Interior status indicators

Each door opening shall be equipped with a means of identifying if a door is not closed and latched. This may be by an indicator at the affected door or in the vestibule.

A car-level diagnostic monitor may be used in addition to or in lieu of the interior indicator.

2.6 Closing warning

Audible and visual warnings shall be initiated at each doorway to warn passengers that the door has been commanded to close.

2.7 Mechanical lock and latch

2.7.1 Door isolation lock

A lock (cutout/lockout) mechanism shall be installed at each door panel to secure a door in the closed and locked position, to provide a door-closed indication to the summary circuit, and to remove power from the door motor or door motor controls.

The door isolation lock shall be key operated or require a key to access and shall not be readily accessible to unauthorized personnel.

The device shall be capable of being overridden by the door emergency release mechanism.

2.7.2 Mechanical door latch

A mechanical device shall be incorporated into the design of the door mechanism to prevent the door from opening until an open command is received or the door emergency release is actuated. The mechanical latch shall be engaged at the end of the door closing cycle and shall activate the door-latched sensor. The latch shall prevent doors from opening should the connection between the drive mechanism and the door supports become compromised or upon loss of power.

2.8 Emergency release

Visual instructions for emergency operations of each exterior side door shall be provided. A manual interior and exterior emergency release mechanism shall be provided at each exterior side door. A clearly labeled emergency release mechanism, when activated, shall unlatch the door, disengage, or unlock the local door isolation lock (if engaged), remove power from the door operator or controls, and allow the door to be moved to the open position. Provision shall be made to allow the door to be moved to the open position after activation of the emergency release mechanism. Examples of such provisions are: a gap that provides a minimum 1.5 in. clearance, a handle, a recess grab, or other means acceptable to the operating railroad. Feedback shall be provided to indicate that the mechanism has been actuated. Examples of such feedback are: movement of the door, orientation of the pull handle, an indicator light, an audible alarm at the door or other means acceptable to the operating railroad.

2.8.1 Design requirements

An emergency release actuation device shall be provided immediately adjacent to the door opening on the interior and exterior of the doorway. Each actuator shall be readily accessible to a person located inside or outside the door opening.

The actuation device shall be covered by a clearly labeled, frangible or hinged panel, to reduce nuisance operations.

The emergency release actuation device shall be readily accessible, without the use of tools or other implement, as per 49 CFR Part 238, (Rail) Passenger Equipment Safety Standards.

The emergency release mechanism shall be capable of unlatching, unlocking, and releasing the door so that the door can be manually opened without power.

The emergency release mechanism shall not require the availability of electric or pneumatic power to activate. The emergency release actuation device shall be readily accessible, without the use of tools or another implement. The force necessary to actuate the interior emergency release mechanism shall not exceed 20 lbf. The force necessary to actuate the exterior emergency release mechanism shall not exceed 30 lbf using a lever-type mechanism or 50 lbf using a "T" handle–type mechanism. When actuated, the emergency release mechanism shall override any local door isolation locks, and it shall be possible to manually open the released door with a force not to exceed 35 lbf. The emergency release mechanism shall require manual reset. No interlock signal (e.g. "low speed" or "zero speed" signals) or mechanism shall prevent the actuation of the emergency release mechanism, except as noted in Section 2.8.1.1.

2.8.1.1 Speed Interlock (Plug Doors and Tier II/III Only)

For plug-type doors on all equipment and all door types on Tier II and Tier III equipment, a speed interlock preventing actuation of emergency release mechanism when the vehicle is moving is permitted, providing the interlock is designed to prevent unintended blocking of the emergency door release in an emergency situation when the vehicle is at standstill. Operating the emergency release actuation device with the interlock active shall not result in actuation of the emergency release mechanism and the emergency release actuation device shall automatically return to or remain in the de-actuated position. The interlock shall be an active system where the default state is the non-interlocked position and shall return to the non-interlocked state in cases of power loss. The interlock shall prevent emergency release mechanism actuation only under the following conditions:

1. Speed signals are received from two independent sources that both indicate car motion, neither of which shall be the no-motion circuit (if axle rotation is used for both sources, reference must be from separate axles); and
2. Control signals are present with consistent logic—e.g., short circuit, open circuit, or contradicting control signals shall not allow false lockout.

Additionally, control signal oversight with a microprocessor-based on-board electronic condition monitoring controls shall be provided.

The electronic condition monitoring controls shall be capable of:

1. Self-health monitoring and display circuit faults; and
2. Disabling the interlock upon loss of power or any contradiction of control signals.

2.9 Markings

2.9.1 Door identification

At or near each door location, there shall be a unique door identifier clearly displayed inside the car.

2.9.2 Emergency egress markings

The emergency release actuation device shall be clearly marked to show its purpose and method of operation as per APTA PR-PS-S-006-23, "Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment"; 49 CFR Part 239, Passenger Train Emergency Preparedness; and 49 CFR Part 238, (Rail) Passenger Equipment Safety Standards.

3. Car-level door design

3.1 Door control stations

One or more door control stations may be provided in a car with powered doors to control the normal operation of the exterior side doors, other doors on that car or other cars in the train via trainline control signals. If provided, the functions, indicators and signage nomenclature shall be equivalent to the door control stations in section 2.1.

3.2 Crew door

Provisions may be provided to allow a local door to remain open or to be opened, when commanded by a crew member, when the door is adjacent to an activated door control station and train speed is below 20 mph.

The door shall automatically close and latch when train speed is above 20 mph or the door control station is deactivated while the train is in motion. The door shall remain closed and latched when train speed drops below 20 mph, until the door control station is activated and a new open command is initiated.

3.3 No-motion/zero-speed system

A system shall be provided to detect when the car is in motion. Motion detection may be local or trainlined.

When motion is detected, opening of all doors on the car (except crew doors) shall be prevented.

3.3.1 Car no-motion bypass

If car-level motion detection is provided, then a local bypass switch may be provided to permit local car doors to be opened with a no-motion system failure. The bypass switch shall be located in an area inaccessible to unauthorized personnel and shall have provisions for sealing in the normal position.

3.4 Exterior indicators

Each vehicle shall be fitted with a minimum of two exterior indicators, one on each side of the vehicle, to visually display that a door is open on that vehicle.

4. Train-level door design

4.1 Door control

Door control stations may be provided in the cab of a passenger locomotive or control cab car. If provided, the functions, indicators and signage nomenclature shall be equivalent to the door control stations in section 2.1.

If the door control station is not provided elsewhere, then the door control station shall be provided in the locomotive or control cab car.

4.2 Door summary circuit

A trainline door summary circuit shall be provided to give an indication in the controlling cab of the train that all exterior side doors are closed and latched, and/or locked out with a door isolation lock.

The door summary circuit shall include a traction inhibit feature that prevents the train from taking traction power when the train is stopped and until all doors are closed and latched and removes traction power from the train should any door open while the train is in motion, except as noted in Section 3.2, “Crew door.”

4.2.1 Door summary circuit bypass

Operating cabs shall be equipped with a door summary circuit bypass switch that, when activated, overrides the door summary circuit.

The summary circuit bypass switch shall have provisions for sealing in the normal position and shall provide an indication, visible to the engineer while seated in the normal operating position, when the train is operating in door summary bypass. The switch may be used to override the door summary circuit in the event that a defective door fails to close and latch and the summary circuit cannot be completed when that defective door is secured using the door isolation lock mechanism, or other trainline failure of the summary circuit. The door summary bypass switch shall have an effect only from the cab controlling the train.

When operating in bypass, the override of the summary circuit shall not compromise any other door safety features.

4.3 No-motion

No-motion protection shall be provided either on a local car-level basis or on a train-level basis.

When train motion is detected, opening of all doors in the train, with the exception of the crew door(s), shall be prevented.

4.3.1 No-motion bypass

A bypass switch may be provided to permit doors to open with a no-motion system failure. If provided, the bypass switch, shall:

- be located in each cab
- be inaccessible to unauthorized personnel
- have provisions for sealing in the normal position
- have an effect only from the cab controlling the train
- have an indicator to indicate when the train is being operated in bypass.

4.4 End-of-train detection

Provisions shall be included to denote the end of the train so that all side passenger doors are protected by the door summary circuit.

If end-of-train switches are used, then the switches shall be secured in a manner to prevent access by unauthorized personnel.

4.5 Trainline interface

Discrete, dedicated trainlines shall be used for door-open and door-close commands, door-enable (if used), door-closed summary circuit, and no-motion, if trainlined. Selected door commands may be transmitted by network.

5. System safety

The door system shall be designed in a fail-safe manner such that no single point of failure shall cause an unsafe condition. In the event of any door system failure, the door system shall default to a safe condition.

A valid door-open command, a valid enable signal (if used) and a valid no-motion signal shall be required to allow a door to open when a door-open signal is generated from an activated door control station.

5.1 Fault tolerance

No single-point failure in the door system, internal to the car or train, shall cause:

- any door to unlatch or open;
- a door-open command to be transmitted or responded to when the train is in motion;
- a door-closed indication to be transmitted when any door is unlatched or open;
- a door-closed indication to be transmitted when an unlatched or opening command is stored anywhere in the system; or
- a speed interlock (as per Section 2.8.1.1), if provided, to prevent an emergency release mechanism from operating.

A hazard analysis shall be performed to validate system safety.

5.2 Design validation

Proof of design tests shall be conducted to demonstrate that the door system complies with the performance and functional requirements specified in this document. A comprehensive series of measurements shall be taken and recorded for all parameters essential to show compliance with this document. These tests shall demonstrate that all specified characteristics and functions are achieved within the specified performance values.

5.3 Labeling consistency

Signage for the side door emergency release actuation device shall comply with the requirements of APTA PR-PS-S-006-23, "Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment," and 49 CFR Parts 238 and 239.

Door signage and indicator functions/colors shall be consistent throughout the train to the extent practical.

Related APTA standards

APTA PR-CS-S-012-02, "Door Systems for New and Rebuilt Passenger Cars"
APTA PR-E-RP-017-99, "27-Point Control and Communications Trainlines Locomotives and Locomotive Hauled Equipment"
APTA PR-IM-RP-003-98, "Door System Periodic Inspection and Maintenance"
APTA PR-PS-S-006-23, "Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment"

References

This standard is to be used in conjunction with the following publications. When the following references are superseded by an approved revision, the revision shall apply.

Code of Federal Regulations (http://www.gpoaccess.gov/cfr/):
49 CFR Part 37, Transportation Services for Individuals with Disabilities (ADA)
49 CFR Part 38, Accessibility Specification for Transportation Vehicles
49 CFR Part 223, Safety Glazing Standards, Locomotive, Passenger Cars, and Cabooses
49 CFR Part 238, (Rail) Passenger Equipment Safety Standards
49 CFR Part 239, Passenger Train Emergency Preparedness.

Department of Defense, Design Criteria Standard, Human Engineering Design Criteria for Military Systems, Equipment and Facilities, MIL-STD-1472E, March 1998. http://www.deepsloweasy.com/HFE%20resources/MIL-STD-1472F%20Human%20Engineering.pdf

IEEE 1475, Standard for the Functioning of and Interfaces Propulsion, Friction Brake, and Train Borne Master Control on Rail Rapid Transit Vehicles, "Definitions, abbreviations and acronyms."

Definitions

bypass: A device designed to override a function.

cutout: A device designed to remove a feature or function from operation.

diagnostic monitor: A monitor that displays the fault status of the systems on a car or a car within the train consist.

door control station: A control panel, activated by a crew key, that provides a train crew the ability to control exterior power–operated side doors either locally and/or via trainline.

door isolation lock: A cutout/lockout mechanism installed at each exterior side door panel (leaf) used to secure a door in the closed and locked position, to provide a door-closed indication to the summary circuit, and to remove power from the door motor or door motor controls.

door pocket: A compartment into which a door panel is retracted when in the open position.

door status indicator: A device visible to the train crew and/or passengers that provides an indication of the status (open or closed) of the door.

door summary bypass: A device designed to override the door summary circuit.

door summary circuit: A trainline door circuit that provides an indication in the controlling cab of the train that all exterior side doors are closed and latched, and/or locked out with a door isolation lock.

enable: A design feature that authorizes operation of the door.

end-of-train feature: A feature used to determine the end of the train or the last passenger car in the train for the door summary circuit.

exterior side door(s): The door(s) on the side of the passenger car normally used for passenger access and egress.

fail-safe: A design feature that shall maintain or result in a safe condition in the event of malfunction or system failure.

inhibit: To prevent the operation of a feature or function.

interface: A point at which two or more systems, subsystems or structures meet to transfer energy and/or information.

latch: A mechanical device used to secure a door in the closed position in normal operation.

leading edge: The edge of a door leading a closing movement.

lock: A mechanical device used to secure a door in the closed position when that door is taken out of service.

no-motion system (zero speed): A system that detects motion of the train or vehicle.

power operation: Door capability that results in the door opening or closing by means of an electric or pneumatic mechanism or a combination thereof controlled from one or more locations.

pushback: A door function that allows the door panel to be moved a specified distance in the open direction by applying a force to the leading edge.

train crew: People authorized to carry out the duties of operating the train.

trainline door circuit: A circuit used to convey door signals over the length of the train.

Abbreviations and acronyms

CFR	Code of Federal Regulations
ETF	Engineering Task Force
IEEE	Institute of Electrical and Electronic Engineers
lbf	pound-force
N	Newtons
NATSA	North American Transportation Services Association
PRESS	Passenger Rail Equipment Safety Standards
RSAC	Railroad Safety Advisory Committee

Summary of document changes

- Document formatted to the new APTA standard format.
- Sections have been moved and renumbered.
- Scope and summary moved to the front page.
- Definitions, abbreviations, and acronyms moved to the rear of the document.
- Two new sections added: "Summary of document changes" and "Document history."
- Some global changes to section headings and numberings resulted when sections dealing with references and acronyms were moved to the end of the document, along with other cosmetic changes, such as capitalization, punctuation, spelling, grammar, and general flow of text.
- Names of participants updated.
- Introduction updated to comply with standard for PRESS.
- Globally, the term "activate" replaced "enable." Activate replaces enable in order to prevent confusion with a door enable trainline or feature that authorizes operation of a side door.
- Section 2.1: Removed the requirement for capturing the key or device when the DCS is activated and replaced with language that allows the designer & train owner to specify if they choose to 'capture' the key but specifies in plain terms that the DCS is activated with key/device in place and deactivated when removed. This section was also expanded to include details on authorizing and de-authorizing a passenger open door function (if desired and equipped). Previously, this document did not specifically call out if a passenger open door function was allowed or prohibited and how its authorized use would be safely controlled by a train crew.
- Former Section 2.2: Duplicated the requirements of Section 2.7.2 (formerly 2.8.2) while specifically requiring that the latch be part of the operator. This may not always be the case and consensus was to remove Section 2.2.
- Section 2.2 (formerly 2.3): In the 1st paragraph, unintentional replaced uncommanded. Uncommanded changed to unintentional as the door latch mechanism functions to prevent a door from opening unintentionally. Unintentional is used elsewhere in the standard to reference latch functionality as well.
- Section 2.4.1 (formerly 2.5.1): Sensitivity locations clarified. Input received from industry indicated that the areas for sensitivity measurement on sliding plug doors should be referenced from door opening versus leading edge. Sliding plug doors are designed with overlap or areas of the leading edge that extend beyond the clear opening of the door (for flush sealing purposes) on the top and bottom. Generally, on the very top of the door opening is where the drive mechanism is located as well. These areas are not exposed to passenger movement or other obstructions.
- Section 2.7.2 (formerly 2.8.2): Added "or upon loss of power" which previously only existed under former Section 2.2, which has been removed as it is redundant and specifies a particular location for the latch. It is a condition that the mechanical latch should protect against.
- Section 2.8 (formerly 2.9): Added "Visual instructions for emergency operations of each exterior side door shall be provided."
- Section 2.8 (formerly 2.9): Added clearly labeled requirement for emergency release mechanism.
- Section 2.8 (formerly 2.9): Clarified that the activation of the emergency release mechanism is only to affect the local door. Changed wording to "allow the door to be moved to the open position" from "move the door toward the open position." Added "Provision shall be made to allow the door to be moved to the open position after activation of the emergency release mechanism." Added additional acceptable means of moving a door to an open position. Added feedback requirement. Testing and feedback from Industry revealed that consistently meeting the 1.5" gap requirement for sliding plug doors is not possible. Discussions from RSAC- ETF in 2017/2018 led to a specific set of requirements that could replace the 1.5" gap while providing an equivalent level of feedback and operability to a passenger using the emergency release. These requirements include clear instructions for emergency release at each door, feedback to the passenger that the release has been activated successfully and a provision that allows the door to be manually moved to the open position. Some

examples of these provisions are provided in the draft. Other provision types would be allowed if acceptable to the operating railroad and approved during the design review process.

- Section 2.8.1 (formerly 2.9.1): Changed title to "Design requirements" from "Design considerations." The emergency release actuation device shall be readily accessible, without the use of tools or another implement." Added requirements for plug-type doors and tier II and III equipment.
- Section 2.8.1.1: New Section added. Justification for speed interlock: Based upon prior incidents on high speed equipment where passengers have opened exterior side doors when the train was operating at speed, the international best practice requires a speed interlock to ensure that doors cannot be manually opened at speed. Requiring doors to be able to be opened while the train is in motion, especially at high speed, creates a significant hazard to passengers onboard, on the platform, or along the wayside due to the significant pressure wave associated with high speed operations. In addition, open plug doors could get damaged and possibly dislodged causing potential impact to other trainsets, people on platforms, and could create the potential for derailments. It is therefore not recommended that plug type doors be absolutely required to open manually when the train is in motion. The specific requirements for the design and the conditions for the operation of the speed interlock for emergency release mechanism have been provided in the draft language. Though single point failures and fault tolerance are addressed in the document for this optional feature, a specific SIL was not assigned to this feature. It was determined that this should be evaluated, assigned, and analyzed on a case-by-case basis as a part of the design and testing of a new vehicle and does not require specific assignment here. Included in this section are details which provide a very specific set of (serial logic) conditions that must be met to allow the interlock to activate while disallowing the interlocks blocking of the emergency release function under any other combination of signals, inputs, power states or mechanical handle positions. The fail-safe or default state shall always be the non-interlocked state.
- Sections 2.1, 3.1, and 4.1: Sections 3.1 and 4.1 were redundant as the same text is presented in section 2.1. Borrowed language from 4.1 to synchronize these 3 sections while removing duplicate text that would need to be changed in multiple sections for any future changes.
- Section 5.1: Added bullet "a speed interlock, if provided, to prevent an emergency release mechanism from operating." It was felt that it was imperative for the emergency release mechanism speed interlock to not fail in a state that prevents emergency release operation due to a single point failure and that it should be added to the existing list of critical features requiring a system safety hazard analysis.
- Former Sections 4.5 (Interoperability between fleets): 49 CFR Part 238.137 addresses operating with a mixed consist. The text served as a suggestion and not a requirement. There were discussions from Industry regarding removing section 4.5 altogether since it is more of a best practice and not a design requirement.
- Former Section 4.6 (Nomenclature): This section contained text that served as a suggestion and not a requirement. There were discussions from Industry regarding removing section 4.6 altogether since it is more of a best practice and not a design requirement.
- Definitions: In the definition of the term enable, "that authorizes" replaced "controlled automatically or manually by the train crew." Refined the definition to better clarify the purpose of the enable, or enable trainline, feature.
- Definitions: In the definition for door isolation lock, "locked" replaced "latched" to be consistent with the use of the two words in the standard. Latched refers to the normal retention of the door in the closed position by the mechanical door latch described in section 2.7.2 (formerly 2.8.2). Locked refers to the securing of the door in the closed position by the door isolation lock described in section 2.7.1 (formerly 2.8.1). This is also in line with the definitions for 'latch' and 'lock' provided in this standard.

Revision 1.1:

- Sections 2.9.2 and 5.3: Changed reference for Emergency signs and markings to APTA PR-PS-S-006-23, “Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment”

Document history

Document Version	Working Group Vote	Public Comment/ Technical Oversight	Rail CEO Approval	Policy & Planning Approval	Publish Date
First published	—	—	—	Oct. 4, 2010	Feb. 11, 2011
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Revision 1.1	July 19, 2019	Sept. 13, 2019	Nov. 4, 2019	Jan. 10, 2020	July 26, 2023

Appendix A: Door closing force measurement

Door closing force

The commanded closing of a power-operated door is a dynamic process, and when the leading edge of a moving door hits an obstacle, the result is a time-dependent dynamic reaction force. The resulting time domain load history profile is influenced by several factors, including but not limited to mass of the door, door acceleration and door dimensions. The following sections define a process for measuring the mean effective door closing force (F_e) and peak force (F_p), as referenced in Section 2.4.

Terms and definitions

closing force (F(t)): Time-dependent force function, measured at the closing edges of the door.

pulse duration (T): Time between t_1 and t_2,

$$T = t_2 - t_1$$

Where, t_1 is the threshold of sensitivity at a point in time where the closing force first exceeds 11.25 lbf and t_2 is the time after t_1 at which the closing force first becomes less than and remains less than 11.25 lbf.

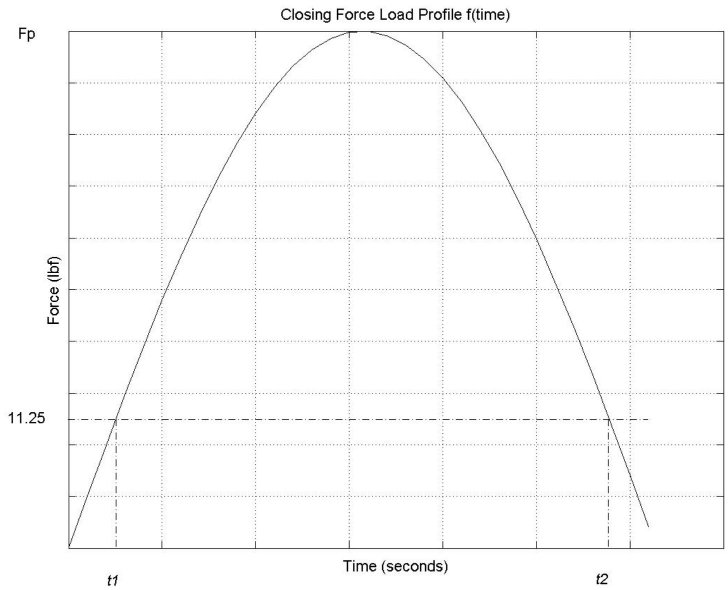
peak force (F_p): Maximum value of the closing force measured within the pulse duration.

effective force (F_e): Average value of the closing force measured within the pulse duration.

$$F_e = \frac{1}{T} \int_{t_1}^{t_2} F(t)\,dt$$

parameter relation: The parameters noted above are depicted in **Figure 1**, where the time-based closing force curve represents an arbitrary shape that may not conform to actual profiles seen in practice. Actual profiles may vary depending on system design and operating specifications.

FIGURE 1
Example Closing Force Load Profile



mean effective force (F_E): The arithmetical mean value of the effective forces, measured at the same measuring point for several trials (*n*).

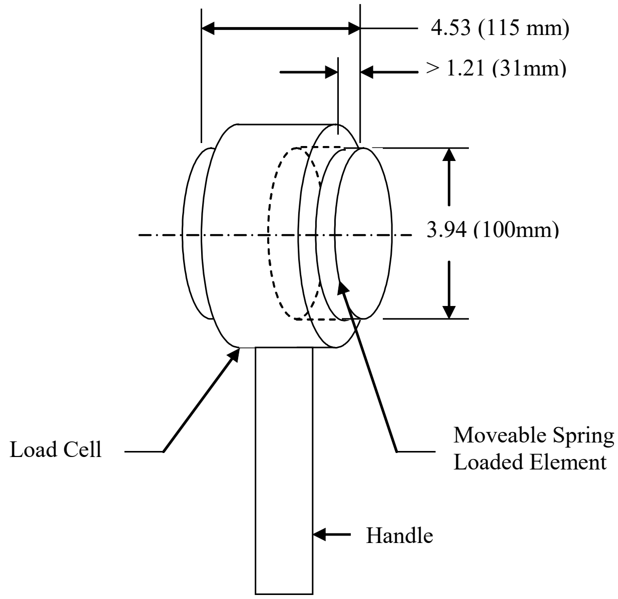
$$F_E = \frac{\sum_{i=1}^{n} (F_e)_i}{n}$$

force measuring device: The force measuring device shall use a load cell for capturing closing force data measured over time. See **Figure 2** for a depiction of an example measuring device.

The measuring device shall have the following characteristics:

- It shall consist of two housings with an outer dimension of 3.94 in. (100 mm) in diameter and 4.53 in. (115 mm) in width.
- As part of the device, a compression spring shall be fitted between the two housings to permit displacement of the load cell along its width in proportion to the magnitude of load applied. The stiffness of this spring shall be 57.1 ± 1.14 lbf/in. (10 ± 0.2 N/mm), with a deflection range sufficient to accommodate maximum peak forces greater than 68 lbf (300 N).

FIGURE 2
Rendition of Example Closing Force (Load Cell) Measuring Device



Force measurement procedure

Conditions of measurement:

- Temperature range: 50 to 86 °F.
- The vehicle shall be positioned on a horizontal, level surface.
- The powered door system shall be operating in a normal condition.

Measurement method: Using a force measuring device (see previous section) held between closing edges of the door, time-dependent measurements of the door closing force at the door middle height shall be taken. Measurement time shall be sufficient to contain the pulse duration (T).

Closing force data provided by the measuring device used for calculations of pulse duration (T), effective force (F_e), mean effective force (F_E) and peak force (F_p) shall be filtered using a low-pass filter with a corner frequency of 100 Hz.

To compute a mean effective force (F_E) as defined above and referenced in Section 2, at least three separate measurements (n = 3) shall be taken at the measuring point.

APTA STANDARDS DEVELOPMENT PROGRAM

STANDARD

American Public Transportation Association
1300 I Street, NW, Suite 1200 East, Washington, DC 20005

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APTA PRESS Electrical Working Group

Emergency Lighting System Design for Passenger Cars

Abstract: This standard specifies the minimum performance criteria for the design of the emergency lighting system for passenger rail cars.

Keywords: emergency lighting, independent power source (IPS), normal lighting, standby lighting

Summary: This standard requires that each passenger rail car be equipped with emergency lighting that facilitates the ability of passengers, train crew members and emergency responders to see under conditions of darkness when the normal lighting power source is unavailable and move within, through and out of the passenger car.

Scope and purpose: This standard applies to all passenger rail cars that operate on the general railroad system in the United States. This standard specifies minimum performance criteria for the design of the emergency lighting system for passenger rail cars that operates when the normal lighting system is unavailable, including minimum interior illumination levels at specified locations and the minimum duration this lighting system must remain on. This standard also requires tests to validate the design.

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List of Figures and Tables

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Introduction

This introduction is not part of APTA PR-E-S-013-99, Rev. 2, "Emergency Lighting System Design for Passenger Cars."

This standard applies to all:

1. Railroads that operate intercity or commuter passenger train service on the general railroad system of transportation; and
2. Railroads that provide commuter or other short-haul rail passenger train service in a metropolitan or suburban area, including public authorities operating passenger train service.

This standard may not apply to:

1. Rapid transit operations in an urban area that are not connected to the general railroad system of transportation;
2. Tourist, scenic, historic or excursion operations, whether on or off the general railroad system of transportation;
3. Operation of private cars, including business/office cars and circus trains; or
4. Railroads that operate only on track inside an installation that is not part of the general railroad system of transportation.

Historically, there have been passenger rail car accidents and incidents that have required the emergency evacuation of passengers and/or train crew members. Review of past passenger rail accidents involving passenger and train crew emergency evacuation has indicated that both passengers and emergency responders lacked sufficient information necessary for expedient emergency egress and access because of the absence of clear markings and instructions. Emergency lighting system failures and/or low levels of illumination during these accidents have been cited as a cause for confusion and as a contributing factor to the injuries and casualties that resulted.

The National Transportation Safety Board (NTSB) made the following recommendation to the Federal Railroad Administration (FRA) after investigation of a 1996 passenger train accident:

> "Require all passenger cars to contain reliable emergency lighting fixtures that are each fitted with a self-contained independent power source and incorporate the requirements into minimum passenger car safety standards (FRA R-97-17)."

In 1999, FRA issued regulations that require emergency lighting for new passenger rail cars (see 49 CFR, Part 238). The FRA regulations state that, for new equipment, minimum levels of emergency lighting must be provided adjacent to doors intended for emergency egress and along aisles and passageways.

This APTA standard was originally developed to provide guidance for meeting the FRA regulations and to specify the design of emergency lighting systems for passenger rail equipment, as well as minimum illumination levels, that will facilitate the ability of passengers and train crew members and/or emergency responders to see and orient themselves, to identify obstacles, and to move safely through a passenger rail car. APTA designed this standard to offer flexibility in application, as well as to achieve the desired goal of facilitating passenger and crew egress from potentially life-threatening situations on passenger rail cars.

This standard is an integral component of a systems approach for locating, reaching and operating emergency exits to facilitate the safe evacuation of passengers and train crew members in an emergency. The other required components of this systems approach include emergency signage and low location exit path marking (LLEPM), which are described in APTA PR-PS-S-006-18, “Emergency Signage for Egress/Access and Low-Location Exit Path Marking of Passenger Rail Equipment.”

Each railroad has the responsibility to ensure that the design, installation and maintenance of the emergency lighting system is compatible with its internal safety policies of emergency evacuation, while complying with the performance criteria specified in this standard. Railroads and car builders should carefully consider the options available to meet emergency evacuation requirements presented in the aforementioned standard.

In addition, recommendations for the design and operation of normal passenger car lighting system design are covered in APTA PR-E-RP-012-99, “Normal Lighting System Design for Passenger Rail Equipment.”

Emergency Lighting System Design for Passenger Cars

1. Types of lighting and power sources

1.1 Normal

When normal power is available, all normal lighting is also available. Normal passenger rail car lighting is powered from some combination of sources derived from head-end power (HEP), auxiliary power or wayside power. Because these sources are generally 480 VAC or higher, the voltage must first be reduced to a suitable operating voltage for a light fixture, usually 240 or 120 VAC. While the bulk of the normal lighting load has historically been AC-powered, frequently the lighting load is now connected directly to the low-voltage DC and battery supply. This has allowed higher car interior light intensity when the HEP/auxiliary/wayside power source is not available, during momentary power losses or even longer intervals, such as during a locomotive change.

Typical lighting power voltages for lighting are 240 and 120 VAC and 74, 37.5 and 24 VDC.

1.2 Emergency

Emergency power is activated when there is a loss of HEP or primary power to a passenger rail car that does not constitute a standby power activation scenario (see Section 1.3 for standby power). Emergency lighting systems shall comply with the illumination levels and duration required in **Table 1**, **Table 2,** and Section 3 and shall be powered by one or more means of an independent power source located in or within one half a car length of each light fixture it powers.

For cars ordered on or after January 1, 2024 or placed into service for the first time on or after January 1, 2028, the independent power source shall either be within each emergency light fixture or, if remote, not directly adjacent to the independent power source for the other half of the car.

> **NOTE:** Emergency lighting systems installed on passenger cars ordered prior to April 7, 2008, or placed in service for the first time before Jan. 1, 2012, may use the main car battery in lieu of independent power sources, regardless of whether or not the main car battery is within half a car length of each fixture.

Batteries that are used as independent power sources shall have automatic self-diagnostic modules designed to perform discharge tests (see Appendix B). After a discharge test is conducted, time shall be provided to recharge the system before placing the equipment back into revenue service. Supercapacitors used as independent power sources shall have a means of identifying a faulty unit, such as a status light, manual testing, etc. These independent sources shall be charged from the normal power sources and shall be capable of operating in any orientation.

1.3 Standby

Standby lighting is powered from the car main battery system and provides near-normal lighting levels when the car has lost main power (typically HEP, third rail or catenary). Standby lighting is intended to keep lighting operational for a period as determined by the purchaser so that a short-term loss of main power will not affect the passengers' and crew's ability to safely move throughout the train. Minimum illumination levels for Standby mode shall be no less than the minimum illumination levels for Emergency mode. Equipment ordered before April 7, 2008, and placed into service for the first time before Jan. 1, 2012, may use standby lighting to fulfill the duration requirement of **Table 1**. Equipment order after this date may not use standby lighting to fulfill the duration requirement of **Table 1** and must use independent power sources separate from the car main battery.

On cars equipped with standby power, emergency power shall be activated if either of the following conditions occurs:

- Standby power is unavailable (such as from system failure or damage).
- Main car battery is depleted from operation of standby mode.

> **NOTE:** Other methods to transition from Standby to Emergency mode may be considered, provided that a hazard analysis is conducted to ensure that emergency scenarios are covered.

Standby lighting systems installed on each passenger car ordered on or after April 7, 2008, or placed in service for the first time on or after Jan. 1, 2012, shall be designed so that if there is a loss of voltage from the main car battery, the emergency lighting system is automatically activated.

> **NOTE:** Although the term is more commonly applied to dedicated systems performing as described above, "standby" as an operational situation can occur under any normal operating scenario in which HEP or auxiliary power can be expected to undergo interruptions as a normal part of operations, e.g., brief ones for phase breaks and third rail gaps, as well as longer ones for locomotive changes, etc. Typically, the extended operating requirements given above are not applicable, but either a portion of the normal lighting does remain active for the short periods of time associated with these expected interruptions, or the emergency lighting system may be activated.

2. Emergency lighting system requirements

The emergency lighting system shall be designed to facilitate the ability of passengers, train crew members and emergency responders to see, orient themselves and identify obstacles in order to enable safe movement within, through and out of a passenger car when normal lighting is not available.

The light sources utilized to comply with the criteria required in Section 2.2 shall be electrically powered (e.g., fluorescent, electroluminescent, incandescent or LED).

2.1 Location

Emergency lighting shall, at a minimum, illuminate the following areas:

- door emergency exit controls/manual releases
- passenger car aisles, passageways, interior stairways
- vestibule floor, passageway and vestibule door thresholds
- exterior side door thresholds, vestibule steps (to facilitate safe entrance/exit from the door)
- end frame door threshold
- diaphragm/inter-car passageway
- restrooms

- crew area of MU/cab car
- galley/cafe
- sleeping car rooms
- other coach/specialty car areas

2.2 Illuminance criteria

Table 1 contains minimum performance criteria for the emergency lighting system for the various areas of the passenger rail car. The values are the minimum values at the end of 90 minutes and 60 minutes, as applicable (see **Table 2**).

Emergency light illumination levels shall be tested in accordance with Section 3 (also see Appendix C). Emergency lighting systems shall be maintained in accordance with Section 6, including periodic retesting.

TABLE 1
Emergency Lighting Performance Criteria, Locations

Area	Where Measured	Conditions Under Which Measured
Initial conditions	N/A	1. The car is to be darkened, either by placing in a dark room without lighting, or by covering the car with opaque materials 2. All exterior doors (exterior side, end frame, etc.) closed 3. All interior doors (vestibule, passageway, toilet, crew office, cab, passenger accommodation, etc.) closed 4. All curtains/drapes to be closed over all windows and doorways where so equipped 5. Upper and lower berths deployed in sleeper accommodations
Door emergency exit controls/ manual releases	At location of emergency/manual door control release and associated instructions[1]	1. Door closed
Aisle (path bordered by seating on both sides)	25 in. (64 cm) above floor at centerline[1], including any steps and/or ramps included along aisle path	1. Doors closed 2. For galley cars, the aisle of the gallery level is considered an aisle
Passageway (path bordered by walls)	25 in. (64 cm) above floor at centerline[1]	1. Door closed 2. On sleepers, all room doors closed
Stairway (interior)	Center of step tread of top landing, middle step, and bottom landing. If there are landings or corner steps where direction of travel changes, center of that step/landing also.	1. Doors closed
Passageway door threshold	Adjacent door, both sides of door	1. Door closed
Vestibule door threshold	Adjacent door, both sides of door	1. Door closed

TABLE 1
Emergency Lighting Performance Criteria, Locations

Area	Where Measured	Conditions Under Which Measured
Vestibule floor	On floor[2]; three readings: 1. Center of vestibule. 2. Center of each trap door, if equipped. If not equipped, halfway between center of car and exterior door interior threshold. 3. For cars with long longitudinal vestibule (gallery cars), three readings spaced equally along car centerline between vestibule bulkheads.	1. Exterior side doors closed 2. Vestibule door(s) closed
Exterior side door threshold	At doors, at floor inside car. Point of doing with door closed and open is to verify that a passenger can locate the door from inside when it is closed and, once open, identify the edge of the car so as to aid in egress without falling.	Test conducted one side at a time. **For cars without traps:** 1. Door closed 2. Door open **For cars equipped with traps:** 1. Trap closed, door closed 2. Trap closed, door open 3. Trap open, door open 4. Trap open, door closed
Vestibule steps	Take reading at center of step tread of bottom and top steps and average readings. If stairway is divided by stanchions, each section is a separate vestibule stairway. For steps that extend outside the envelope of the car, each step must be measured individually.	1. Exterior side door open
End frame door (blind end door and collision post door) threshold	Adjacent door, inside car, and adjacent door, outside car	1. End frame door closed 2. Exterior side doors closed
Diaphragm[2]	At the center of the floor, even with the collision posts	1. Collision post door open, if there is a door 2. Light from adjacent area is allowed to contribute
Gangway[2]	25 in. (64 cm) above floor at geometric center[2]	1. Light from adjacent area is allowed to contribute
Restroom area	25 in. (64 cm) above floor[1] **Non-ADA room:** Approximate center of room (this also includes sleeper room toilets when separate room) **ADA toilet:** Average of three readings approximately evenly spaced	1. Door closed
Crew area of MU/ cab car	On floor: • Exit path to each exit door • On each stair step enroute to exit door • On each door threshold higher than 1 in.	1. Cab door closed to passenger area

TABLE 1

Emergency Lighting Performance Criteria, Locations

Area	Where Measured	Conditions Under Which Measured
Galley/cafe behind counter	25 in. (64 cm) above floor[1] Path along centerline of serving area and/or food preparation area. Several readings, evenly spaced, minimum three.	1. As set up for serving passengers 2. For diner galley, serving door open, but crew access door closed
Sleeping car passenger rooms	25 in. (64 cm) above floor, but not less than 1 in. above surface of lower berth, approximate center of the open floor area of the room remaining with berths down. (This may need to be customized slightly based on the actual floor plan. The intent is to verify that there is sufficient light for the passenger to orient themselves and locate the door to the hallway.)	1. Room access door closed.
Other coach/ specialty car areas	25 in. (64 cm) above floor[1], approximately in center of open area	1. Door closed

1. Values for these areas are averages of all the measurements made. For equipment ordered on or after Sept. 8, 2000, or placed in service for the first time on or after Sept. 9, 2002, no single measurement shall be less than one-tenth of the values in **Table 2** (i.e., 0.1 fc (1 lx) initially and 0.06 fc (0.6 lx)) after 90 minutes. For equipment ordered before Sept. 8, 2000, and placed in service before Sept. 9, 2002, no single measurement shall be less than one-tenth of the values in **Table 2** (i.e., 0.05 fc (0.5 lx) initially, and 0.03 fc (0.3 lx) after 60 minutes. See Section 3.3.3.3.

2. Applies only to new equipment ordered after January 1, 2024, or placed into service for the first time after January 1, 2028.

Note: Cars built and tested before new requirements went in effect do not need to be retested unless specifically identified.

TABLE 2

Minimum Emergency Lighting Performance Criteria, Light Levels

Effective Dates	Intensity Required (fc [lx])		Duration Required (minutes)	Power Source	Power Source Placement
	T=0	T=Duration			
Ordered before 9/8/2000, placed in service before 9/9/2002	0.5 (5.4)	0.3 (3.2)	60	Can be car battery	
Ordered on or after 9/8/2000, or placed in service for the first time after 9/9/2002	1.0 (10.8)	0.6 (6.5)	90	Can be car battery	
Ordered after 4/7/2008 or placed in service for the first time after 1/1/2012[1]	1.0 (10.8)	0.6 (6.5)	90 (standby power no longer counts toward emergency lighting requirement)	Backup power sources must meet the performance requirements for independent power sources	Independent power source(s) within one-half car length of each fixture
Placed in service for the first time after 1/1/2017	1.0 (10.8)	0.6 (6.5)	90	Must use *only* independent power sources	Independent power sources within one-half car length of each fixture

TABLE 2
Minimum Emergency Lighting Performance Criteria, Light Levels

Effective Dates	Intensity Required (fc [lx])		Duration Required (minutes)	Power Source	Power Source Placement
	T=0	T=Duration			
Ordered on or after 1/1/2024 or placed in service for the first time after 01/01/2028	1.0 (10.8)[2]	0.6 (6.5)[2]	90	Must use *only* independent power sources	Independent power sources must not be adjacent to each other

1. Standard cited in 49 CFR 238.115 on November 29, 2013.
2. Includes diaphragm and inter-car areas.

2.3 Duration

Emergency lighting systems shall operate all emergency lighting for a period of at least 90 minutes without a loss of more than 40% of the minimum illumination levels specified or 60 minutes without a loss of more than 40% of the minimum illumination levels specified for cars ordered before Sept. 8, 2000, placed into service prior to Sept. 9, 2002.

Emergency lighting systems installed on passenger cars ordered prior to April 7, 2008, or placed in service for the first time before Jan. 1, 2012, may use the main car battery in lieu of independent power sources, regardless of whether or not the main car battery is within half a car length of each fixture, and shall comply with the former definition of emergency lighting. This means that these cars may utilize standby power to fulfill the illumination duration and intensity requirements in part or in total.

All cars ordered on or after April 7, 2008, or placed into service for the first time on or after Jan. 1, 2012, shall be equipped with independent power sources that fulfill the illumination duration and intensity requirements without aid from the main car battery and shall comply with the current definition for emergency lighting.

The time at which the clock is started for timing the lighting duration is as specified in **Table 3**.

TABLE 3
Clock Starting Times

Lighting Mode	When Clock Starts	When Clock Stops
Standby power	When HEP or auxiliary power is shut off.	At fully elapsed test duration time, or when any light goes out, whichever comes first. Note: Since standby lighting is optional, there is no formal requirement in this document for duration; intensity is quantified, however.
Emergency, car equipped with standby power	When standby lighting goes off (i.e., main battery is fully discharged or timeout occurs).	At fully elapsed test duration time, or when any light goes out, whichever comes first.
Emergency, car without standby power	When HEP or auxiliary power is shut off.	At fully elapsed test duration time, or when any light goes out, whichever comes first.

3. Evaluation measurements and tests

To verify design and compliance with the minimum emergency light level requirements in **Table 1** and **Table 2**, railroads shall ensure that a qualification test is conducted on at least one representative car/area for each emergency lighting system layout, in accordance with this section and Appendix C.

This test shall be completed before the equipment is released for operation in revenue service.

3.1 Qualification test (initial verification)

This is an engineering proof-of-design test conducted on one of the following:

- a brand-new car before it is placed into service
- an existing car that has had the power source and/or the standby/emergency light fixtures modified or replaced (see Section 3.6), different from that when the car last had a qualification test (refer to **Table 4** for an explanation of required retesting.

This test is typically done on one new car. If several similar car types are part of the same order, one complete car from the order must be tested for light intensity as well as the areas unique to each of the other car types such that light measurements of all locations in **Table 1** are taken. Each car type shall be tested for duration.

> **NOTE:** For example, if one car was a coach and another a food service car with the rest of the car having seating identical to the first coach car, only the food service area would need to be tested on the second car.

This test shall be conducted to demonstrate the system performance of emergency lighting system from each power source, including main battery and/or independent power sources as applicable.

3.1.1 Test procedure

A detailed step-by-step test procedure is required to conduct the lighting test. It shall include the following, at a minimum:

1. Purpose (new car qualification, partial car qualification, etc.)
2. Equipment on which it will be conducted (typically car number series)
3. Any references required, such as drawings, etc. (lighting arrangement drawing)
4. Prerequisites for the test (identifying the state of the car to be tested: light fixture lenses clean, new lamps, battery condition, etc.)
5. Test equipment to be employed (light meter, multimeter, etc.)
6. Initial conditions required (include sketch identifying exact site of each measurement; refer to **Figure 3** in Appendix C.4)
7. Step-by-step procedure for taking the measurements
8. Data sheet to record readings (refer to **Figure 3**)
9. Final conclusion with signatures of those conducting/witnessing the test

For an example test procedure, see Appendix F.

3.2 Battery emulation

> **NOTE:** A regulated DC power supply may be substituted for the main battery to conduct the test if done in accordance with the following procedure:

3.2.1 Battery discharge

Voltage drop in car wiring must be taken into account when establishing the DC bus voltage measurement site. This is to ensure that the voltage actually feeding the lighting loads is the same whether the battery or DC power supply is powering the loads.

If the power supply will feed the entire car DC load, the measurement point can be at the battery leads at the battery or charger, or at the DC circuit breaker panel.

If the DC power supply will be feeding only the lighting loads (not the full DC load), the measurement site must be the DC bus (such as the line side of the DC main circuit breaker on the DC power distribution circuit breaker panel).

1. Connect a digital voltmeter with accuracy of 0.1% or better to this exact site. Record the location on the data sheet.
2. Activate all DC loads that are active when the car is in revenue service. In the case of a cab car, this includes all cab loads, including headlight, auxiliary lights (continuously on, not flashing), event recorder, alerter, PTC, etc. For non-cab cars, activate any end-of-train functions, such as marker lights, looping relays, etc.
3. Fully charge the power source(s) to a full state of charge as per OEM instructions.
4. Shut off all auxiliary power (HEP) to the car; immediately start a timer set for the duration specified in **Table 2**.
5. Allow the car emergency lighting and all other DC loads to function. Load shed should function as per design over the duration required in **Table 2**. At the end of that duration, read and record the voltage from the meter on the data sheet.
6. Remove battery power from the car and isolate the leads. Connect the regulated power supply to replace the battery feed. Keep the same meter used earlier connected to the same point.

   NOTE: If the power supply is unable to provide the full load battery current, it is acceptable to disconnect the nonemergency lighting loads by opening the respective circuit breakers. Note this in the test report, as applicable.

7. Power up the power supply and adjust the output voltage to exactly match that measured on the digital meter in step 5.
8. Continue with intensity test procedure, step 3.4.

   NOTE: The light intensity of the lighting fixtures fed from the main car battery is dependent on the voltage at the fixture. Since there is voltage drop in the car wiring from battery to the distribution point (typically DC circuit breaker panel), this must be taken into account when the regulated power supply is substituted for the battery.

   NOTE: The voltage drop in car is dependent on load current, as long as the voltage feeding the DC lighting loads is the same at the distribution point as it would be with the full load borne by the battery.

3.3 Preparation for tests

3.3.1 Car preparations

The car to be tested is to be in condition suitable to conduct the test accurately under known, reproducible conditions.

3.3.1.1 Light fixtures

1. Lenses must all be in place and clean.
2. Incandescent and fluorescent lamps should be new; the latter shall be aged for at least 100 hours before the test to ensure that they achieve full light level.

3.3.1.2 Car interior

1. Car shall be configured and equipped as it would be in ready for revenue service, but can be free of consumable items.

3.3.1.3 Battery system

Information shall be recorded identifying date of manufacture and time in service of main and independent power source batteries.

Main battery

1. Main battery shall be clean, with fluid levels topped up as required.
2. Battery shall be fully charged, as identified by the manufacturer

Independent power sources

1. These shall be fully charged, as identified by the manufacturer

3.3.1.4 Temperature

1. Temperature shall be within the range of normal operating temperatures as recommended by the test equipment manufacturer.
2. In addition, the car lighting system shall be under power for at least 15 minutes before the test is started to warm up fixtures to the temperature they would experience in normal operation.

3.3.2 Initial conditions

1. The car shall be configured as indicated before beginning the light level measurements. The intent is to configure the car in test to simulate it being disabled in a dark area, on a clear, moonless night. The car should be arranged to depict it as it would be in typical revenue service. In addition, the individual reading locations are intended to be areas of interest to a passenger attempting to exit the area. For example, finding the emergency release instructions are relevant only if the door is closed.
2. All extraneous light shall be excluded to the extent practicable. Meaningful data can be collected only if ambient light can be eliminated almost completely from the areas being measured. Any approach is acceptable as long as ambient light is reduced below 0.01 fc (0.1 lx) in the areas being measured.
3. If the ambient light cannot be reduced to 0.01 fc (0.1 lx), there are two alternative measurements that can be used to meet the requirements in **Table 1** and **Table 2**:
   - Measure the ambient light at each location and subtract that value from the value measured with the emergency lighting operating.
   - If the emergency lighting is at least twice the required levels in **Table 1** and **Table 2** plus the ambient light reading, consider the required levels to be met.

The method of darkening the car can be one or a combination of the following:

1. Place car in a windowless shop facility where all shop lighting can be extinguished to make it completely dark (climate room, paint booth, carwash, test area, etc.).
2. Secure the car to be tested so it does not move; parking brake applied, chocks at wheels. Blue flag as required.

3. Place car in an area where it will not be disturbed. Cover all car exterior windows with opaque coverings, such as a tarpaulins, cardboard, etc. Use care when covering exterior lights such as headlights, auxiliary lights, marker lights, etc., as they can get very hot and melt coverings or even cause a fire.
4. Do not darken any windows within the car body such as vestibule windows.
5. For any cars equipped with drapes/curtains over side windows, these shall be closed fully throughout the car.

Requirements for doors:

1. All exterior-facing doors shall be closed: exterior side doors, end frame doors, stock loading doors/hatches, etc.
2. All interior doors shall be closed: vestibule, passageway, toilet, galley access, cab, etc. For cars equipped with individual rooms, such as sleeping cars, these doors shall be closed. Any curtains/drapes on windows of these rooms shall be fully closed.
3. Unless allowed during a particular measurement or required to access a reading location, all doors shall be closed for the duration of the test.

Mark locations where readings will be taken:

1. To expedite taking readings, the site of each required reading should be marked on the car, such as through the use of nonreflective masking tape or stickers. It is helpful to number each site.
2. For the 25 in. height, a small stand should be created upon which to place the light sensor.
3. For semi-permanently coupled trainsets, the testing of the semi-permanently connected areas must be addressed in the test plan.

Configure car power system for test:

1. All the battery loads that may be applied under emergency conditions shall be identified. Circuit breakers shall be set so that those loads (door operators, PA system, controls, headlights or marker lights, etc.) that are normally present in revenue service are energized during the emergency lighting tests.
2. The tests shall be conducted with battery power only; any feeds from HEP, auxiliary or wayside sources shall be disconnected.

   NOTE: APTA PR-E-RP-007-98, "Storage Batteries and Battery Compartments," contains additional guidance for the conduct of car main battery tests.

3.4 Data collection

When testing the illumination of a car, a record shall be taken of the condition of the car and the method of making the test. As a minimum, this information shall include the following:

1. Number of car
2. Car type (e.g., Superliner-1 Sleeper)
3. Location where test is conducted: geographic location and where (e.g., in car wash building in Amtrak 14th Street shops, Chicago)
4. Date of original manufacturer or date car is placed in service
5. Identification of individual(s) conducting test
6. Dates test conducted
7. Time of day

8. Car interior air temperature
9. Outside ambient temperature
10. Start and end times
11. Method of darkening car (photos may be attached as reference)
12. Instruments used:
    - Manufacturer and model number
    - Serial number of instrument
    - date of last calibration
    - whether or not equipped with color correction filter
13. Identification of area tested (e.g., entire car, vestibule, aisle, passageway)
14. Type of lighting fixtures and record of which fixtures were lighted
15. Location of readings (need an illustration to show this; could be lighting arrangement drawing)
16. Individual illumination level measurements taken

NOTE: It is recommended that the following information be recorded:

- Condition of fixtures
- New or old
- Type of reflector and condition
- Cleanliness
- Wattage and rated voltage of lamp
- Color temperature or manufacturer's model number of lamps
- Battery voltage

This information must be included with the test procedure documentation. A copy of such documentation is an acceptable record.

Appendix C contains a data sheet form suitable for recording all the above information.

Appendix D describes steps to follow if the illumination levels do not meet the criteria specified in sections 2 and 3.4.

3.5 Procedures for measuring illuminance of emergency lighting systems

Measurements of the emergency lighting system performance in most locations shall be taken as spatial averages in the immediate vicinity of an action point, as specified in this section. No single reading used in the spatial average shall be below 0.1 fc (1 lx) (i.e., no dark spots are allowed). The action points considered within this standard are at the door exit release, at armrest level (25 in. [64 cm] above the floor), on the floor, and at specified stairway step locations. As identified below, some specialized areas require only single readings rather than averages.

NOTE: Each section below specifies the minimum number of illuminance measurements required in a particular area of a car. Railroads and car builders are permitted to take more measurements and calculate averages of such measurements.

3.5.1 Required equipment

To ensure accurate illuminance measurements, including measurements on vertical surfaces at which the angle of incident light is large, the light meter must be designed to take such measurements and possess the following:

- **Basic accuracy:** ±3% of reading ±1 digit or better
- **Resolution:** 0.01 fc (0.1 lx) or better
- **Cosine error:** No more than 6%, measured at 50 deg.
- **Color correction:** To CIE photopic curve

To ensure that the close proximity of the person taking the measurements does not affect the readings, unless the floor measurement value is known to be at least five times the value in **Table 1**, a 6.5 ft (2 m) separation between the sensor head and the display must be used. If the measuring apparatus is unlit or if there is no light emitted from the apparatus, the 6.5 ft (2 m) requirement need not apply.

Other required equipment includes a notebook computer or data logger to capture the data stream from the illuminance meter in order to determine the average illuminance levels, small flashlights suitable for reading the instrument displays without introducing significant additional light and a stopwatch. (Appendix C contains a sample data collection form that includes all necessary data items.)

NOTE: Clipboards, a personal audio recorder and data collection forms are also useful.

3.5.2 Data collection timing

The car emergency lighting illuminance performance readings shall be taken at the start of the test after the emergency lighting is activated, and again at the end of the final applicable time duration. All data shall be recorded. For cars with standby lighting as well as emergency lighting, separate tests must be conducted on each system. Note that standby lighting, since it is not a requirement, does not have a duration requirement, only intensity.

An acceptable alternative to using the main car battery for the 60- or 90-minute measurements is to characterize battery voltage performance as a function of battery discharge time, as long as the other factors that affect the performance of lighting systems are considered (see Appendix E). The discharge curve of the battery in a particular car can be measured, and then an external power supply can be used to deliver a fixed voltage corresponding to a particular point in time on the discharge curve. Illumination measurements can be conducted using those voltage points at a later convenient 60 and 90 minutes (see **Table 1**). Refer to Section 3.2 for details of this technique.

Alternatively, there exists a limited case of an emergency light system design that utilizes constant power emergency lights with no dimmer circuit. The emergency light levels over the entire 60- or 90-minute test period remain static at the action points. For such designs with static emergency light levels at the applicable action points, only the initial light level measurements need be recorded, with the emergency lights permitted to discharge for the rated 60- or 90-minutes test period. The same initial measurements may also be used as the final set of measurements in lieu of recording a final set of measurement data in order to justify emergency light level compliance in accordance with **Table 1**.

3.5.3 Required measurement locations

To take the measurement readings, the sensor is placed on the locations listed in **Table 1**, using adhesives or supports if necessary. The observer simply records the reading(s) using a form similar to that contained in Appendix C.

The sensor and the readout device of the illuminance meter must be held or positioned in a manner so that the sensor is not affected by the observer's shadow.

3.5.3.1 Door exit control/manual release instructions

The measurements shall be taken directly on the surface of the location of the door control/manual release and on the surface of the instructions.

As an alternative, measurements may be taken with a meter with basic accuracy of 3% or better (but not necessarily with accurate cosine correction) with the sensor placed flat on the floor at any point within a horizontal distance of 3 ft (0.9 m) from the door control. The illumination value shall be at least five times greater than listed in **Table 1**.

3.5.3.2 Aisles and passageways

Because emergency lighting illumination levels may vary within a car, an average based on measurements taken no more than every 4 ft shall be taken for each aisle or passageway at equidistant intervals along the aisle centerline at a height of approximately 25 in. (64 cm) above the floor to represent the mean illuminance level throughout the car length. Measurements shall be taken with the vestibule, passage and end frame doors closed.

To ensure that each minimum illuminance level measurement used to determine the spatial average is at least 0.1 fc (1 lx) or 0.05 fc (0.5 lx), as applicable, at the beginning of the test and 0.06 fc (0.6 lx) or 0.03 fc (0.3 lx), as applicable, at the end of the test, the measurements shall be taken at each marked location equally spaced along the aisle in the spot that appears darkest to the observer. Whether measurements are recorded manually or by computer, they should be taken in a manner such that the observer's shadow does not affect the readings.

> **NOTE:** If measurements are to represent system performance at a given point in time along the battery discharge curve, these readings must be collected within a short time period. Collecting this quantity of readings manually is difficult to accomplish quickly. Therefore, the computerized data collection method described in Appendix B is recommended.

3.5.3.3 Interior stairway

For interior stairways, a measurement shall be taken on the tread near the geometric center at the top landing, at a step in the middle of the stairway and at the bottom landing. An average of these three measurements shall be recorded. If there are landings or corner steps where direction of travel changes, each segment of the stairway between the changes and direction shall be treated as an individual stairway. Any nearby door shall be closed.

3.5.3.4 Passageway and vestibule door threshold

Measurements shall be taken on the floor at the center of each door threshold with the door closed, on both the inside and outside of the door.

3.5.3.5 Exterior side door threshold

The objective of taking readings with the door closed and then open is to verify that passengers can locate the door from inside when it is closed and, once the door is open, identify the edge of the car so as to aid in egress without falling.

The measurements shall be taken on the floor inside the car at the center of each exterior side door threshold. The measurements are to be conducted one side at a time, as follows:

For cars without traps:

- Door closed
- Door open

For cars equipped with traps:

- Trap closed, door closed
- Trap closed, door open
- Trap open, door open
- Trap open, door closed (if car so equipped)

3.5.3.6 Vestibule floor

The arrangement of the vestibule area of cars varies greatly among car types, including some with traps.

Readings shall be taken on the floor as follows with all doors closed:

- Geometric center of the vestibule (for cars with exterior doors within the seating areas, this reading may be the same one taken for the aisle/passageway)
- Approximately longitudinal center and 30 in. from the inside surface of the exterior side door, both sides of car

An alternative:

- For cars that have long vestibules, with fixed stairs and no traps on both sides (such as gallery cars), three readings along the centerline of the car, evenly spaced between the vestibule bulkheads

3.5.3.7 Vestibule steps

For cars with steps for non-level boarding, measurements shall be taken near the geometric center at the top step and threshold of the bottom step. An average of these two measurements shall be calculated. The measurement of the bottom step can be done with the adjacent exterior door open, but all extraneous light sources must be handled as per Section 3.3.

If a stanchion divides the side doorway entrance into two or more sections, each section shall be treated independently and measured separately. For example: A stanchion separates the doorway entrance into two sides. The measurements shall be taken on each side of the stanchion respectively. The measurements shall be taken at the center of each divided section.

For steps that extend outside the envelope of the car, each step must be measured individually.

3.5.3.8 End frame door threshold

Blind end doors are those providing access to the neighboring car when there is no intervening vestibule. Collision post doors are those used to close off the diaphragm area of a car when that end of that car is at the front or rear of the train.

For equipment ordered on or after January 1, 2024, or placed into service before January 1, 2028, the end frame door threshold measurement shall be taken on the floor at the center of each door on the inside.

For equipment ordered on or after January 1, 2024, or placed into service before January 1, 2028, the end frame door threshold measurement shall also be taken on the outside of the car at the door threshold with the door closed, but all extraneous light sources must be handled as per Section 3.3.

For collision post doors, the measurements shall be taken with the vestibule door closed and exterior side doors closed.

3.5.3.9 Inter-car passageways

There are three basic types of inter-car passage:

- **Conventional:** Walkway enclosed by two diaphragms, one on the end of each car. These accommodate relative angular, lateral and vertical displacement between the ends of cars by means of sliding buffers at the floor level and by sliding diaphragm faceplates or tubular sliding diaphragms at the sides and top.
- **"Gangway":** Walkway enclosed by a continuous bellows/diaphragm that is sufficiently flexible to accommodate relative angular, lateral and vertical displacement between car bodies. This is typically employed on semipermanently coupled or articulated (angular motion only) cars.
- **Open:** Walkway unenclosed; relative lateral and vertical displacement of the floor between the ends of cars accommodated by means of sliding buffers and employing chains (or equal) on the sides between cars. This approach is used in scenarios such as facing cab end to cab end where passengers do not normally move inter-car.

Gangways generally are sealed from weather and have a wide path, while conventional diaphragms are narrower and less fully enclosed. These paths allow passenger/crew to safely move between coupled cars. The light level on the conventional type is measured at floor level, as there is a potential trip hazard there, while the gangway is measured at 25 in. because it functions more like a passageway.

Light levels shall be measured as follows:

- **Conventional diaphragm:** At the center of the floor, within the center of the longitudinal range of the collision posts, end frame door open if there is a door. Light from adjacent car area is allowed to contribute. The open face of the diaphragm is covered or open to the dark outside.
- **Gangway:** At 25 in. (64 cm) above floor at centerline, midway through the gangway.

For equipment ordered on or after January 1, 2024, or placed into service before January 1, 2028, the diaphragm light levels shall be measured on the floor in the geometric center of the diaphragm. The end frame door shall be closed, but illumination from the emergency lighting inside the car can contribute to the emergency lighting levels through the window in that door.

3.5.3.10 Restroom

Inside the restroom area, the measurements shall be taken at a height of approximately 25 in. (64 cm) above the floor with the door closed. For a non-ADA restroom, which is typically quite small, a single reading in the approximate center of the room is adequate. For an ADA restroom, an average of at least three or more measurements shall be measured and be used to determine a spatial average.

3.5.3.11 Crew area of MU/cab car

While there are a wide variety of cab area configurations within passenger cars, three activities are possible, depending on car configuration:

- Operating crew using cab
- Passengers occupying seat(s) in cab area of dual mode (convertible) cab
- Passengers and/or crew exiting car via cab area

A dual mode cab is defined as one that can be configured either as an operating cab, and when not functioning in that role can be configured for passenger seating or pass-through to the body end frame door.

For cars with cabs ordered on or after January 1, 2024, or placed into service before January 1, 2028, the measurement of the inside of the cab area shall be taken as follows:

Cab (crew operating train)
This is defined to be either of the following:

- Dedicated cab, used only by operating crew
- For convertible cabs, the operating mode when the cab is set up to control the train and is closed off to passengers

The cab emergency light levels are taken at floor level, as follows:

- The exit path from each seat to each exit door
- On each stair step to be negotiated to the exit door
- On each door threshold higher than 1 in.

> **NOTE:** The locations of requirements are traceable to AAR Standard S-580, "Locomotive Crashworthiness Requirements."

With a blind end cab, since there is no pass-through possible to the adjacent car, the only emergency lighting measurements are those required for Cab mode.

Convertible cab: passenger seating mode
When the cab is configured in this mode, the passenger seating and aisle/passage light requirements are defined by Section 3.5.3.2. For this mode, aisle/passageway measurements need be done only once, with the cab area configured for passenger seating. A separate aisle/passageway test conducted with the cab isolated is not required.

Convertible cab: pass-through mode
When the cab is configured in this mode, aisle/passage light requirements are defined by Section 3.5.3.2. For this mode, aisle/passageway measurements need be done only once, with the cab area configured for pass-through. A separate aisle/passageway test conducted with the cab isolated is not required.

3.5.3.12 Galley/cafe behind counter

In the galley area, with the car configured to service passengers, the measurements shall be taken at a height of approximately 25 in. (63.5 cm) above the floor along the path of the approximate center line of the serving area or food preparation area, taken no more than every 4 ft (1.2 m). The crew door and any serving counter security gate/screens/panels, etc. shall be in the normal position when the galley is active.

3.5.3.13 Sleeping car passenger rooms

The measurement shall be taken at a height of approximately 25 in. above the floor, but not less than 1 in. above the surface of the lower berth, approximately in the center of the open floor area of the room remaining with berths down. (This may need to be customized slightly based on the actual room floor plan. The intent is to verify that there is sufficient light for the passengers to orient themselves and locate the door to the hallway.)

The door to the passageway shall be closed. If there is a toilet room within the accommodation, this door shall be closed. Curtains/drapery in the room shall be closed, covering all the windows. This applies to interior windows as well as windows to the exterior of the car.

3.5.3.14 Other coach/specialty areas

The measurement shall be taken at a height of approximately 25 in. above the floor, approximately in the center of the open floor area of the room. The door shall be closed.

3.5.3.15 Multilevel cars

Illuminance measurement readings shall be taken at the required locations on each main level and each other-than-main level of multilevel cars (e.g., intermediate, mezzanine).

3.6 Retesting emergency lighting

When portions of the car emergency lighting system are altered, overall system performance may change. Accordingly, some or all of the system may need reverification. Retesting requirements are as shown in **Table 4**:

TABLE 4
Retesting Requirements

System Change	Retesting Requirement	Rationale
Battery capacity increased, or electrical load on battery reduced	No tests required	
Battery capacity reduced from original	Duration test only	Intensity not changed, but duration may be affected
Battery charger changed for different model or rating	Duration test only	Intensity not changed, but duration may be affected
Battery load increased (e.g., new equipment added)	Duration test only	Intensity not changed, but duration may be shortened
Reconfiguration of car interior (e.g., replace restroom)	Intensity of affected areas test plus duration test	Since only a small area of the car is affected, only that portion needs intensity; battery load might change and reduce duration
Relocation of existing emergency lights, using same fixtures and quantity	Intensity of affected areas test only	Intensity may have changed, but duration has not been affected
Local replacement of existing lights with different light source (i.e., LED), or fixture (e.g., new vestibule lights)	Intensity of affected areas test plus duration test	Battery load may have changed
Whole-car replacement of existing lights with different light source (i.e., LED) or fixtures	Full retest: intensity plus duration	This is in effect a new installation and as such requires a full qualification retest

For the purposes of **Table 4**, “battery” refers to the battery and/or independent power source, including supercapacitors providing power to the emergency light(s) in question. Likewise, “battery charger” refers to the associated equipment used to charge the above battery or supercapacitors. Changes of any batteries on the car that are not associated with the emergency lighting system do not require any retest of emergency lighting equipment.

When duration testing is required, only a single car of each car type in which the change is applied need undergo duration testing.

When illumination testing is required, at least one example of all affected areas shall be tested. For example, if only the lavatory emergency lighting configuration is changed, only the lavatory need undergo illumination testing as the rest of the car is unaffected. The areas tested need not be from a single car.

> **NOTE:** If it can be proved through calculations and analysis using archival or measured battery load data that the added battery load does not result in the emergency battery capacity being within 10% of the 90-minute requirement, a duration test is not necessary. For example, if the added battery load results in a calculated battery capacity of 95 minutes, a duration test must be performed. If the calculated battery capacity after including the added battery load is greater than 99 minutes, a duration test is not necessary.

3.7 Recordkeeping

Railroads shall retain a copy of the test procedure describing the method used to obtain the measurement readings and a copy of the test data showing the illumination levels measured at the required locations, and the results of such tests.

Railroads shall retain a copy of the test results until the next periodic test is conducted on a representative car/area, as required by Section 6, or until cars of that type are retired, or are transferred, leased, or conveyed to another railroad. A copy of such records shall be transferred to the accepting railroad along with any such car(s).

4. Operating conditions

The required illuminance criteria shall be met under normal operating conditions.

> **NOTE:** Operating practices should take into account that the frequent deep discharges of the battery, (e.g., "pulling the plug" on HEP at the end of each trip), whether from main and/or IPS, may have an adverse effect on their life expectancy.

For passenger cars ordered on or after Sept. 8, 2000, or placed in service for the first time on or after Sept. 9, 2002:

1. Each main car battery and each independent power source shall be capable of operating in all equipment orientations within 45 deg. of vertical, and after the initial shock of a collision or derailment resulting in the following individually applied accelerations:
    - longitudinal: 8g
    - lateral: 4g
    - vertical: 4g
2. Emergency lighting system components shall be designed to operate without failure under the conditions typically found in passenger rail equipment including expected mechanical vibrations (as defined by IEC 61373-1) and shock, as well as comply with electromagnetic interference and other criteria in 49 CFR Part 238, Passenger Equipment Safety Standards, Sections 238.225, 238.425 and 238.725.

For each passenger rail car ordered on or after April 7, 2008, or placed in service for the first time on or after Jan. 1, 2012, all emergency lighting system components shall be designed to operate in all car orientations.

Tier III trainsets are subject to acceleration requirements contained in 49 CFR 238.743.

5. Maintenance

5.1 Maintenance requirements

After the initial qualification (verification) tests required by Section 3, railroads shall ensure that periodic tests to confirm the minimum illumination level and duration of the emergency lighting system are conducted no less frequently than once every eight years. A representative sample of cars or areas per ANSI/ASQC Z1.9-1993 shall be tested using the procedures in Appendix E.

Railroads shall ensure that periodic inspections at least every 184 days, including a functional test of the system, are conducted of the emergency lighting system, including all power sources. Deference of inspections are allowed for out-of-service rolling stock in accordance with 49 CFR 238.321.

> **NOTE:** Criteria for acceptable main car battery characteristics are specified in APTA PR-E-RP-007-98.

5.1.1 Maintenance practices

Railroad maintenance shall ensure that all emergency lighting system components are kept in a state of good repair so that when called upon, the system will function with the intensity and duration expected.

> **NOTE:** Maintenance practices shall take into account that the frequent deep discharges of the battery (e.g., "pulling the plug" on HEP at the end of each trip), whether from main and/or IPS, may have an adverse effect on their life expectancy.

For light fixtures, this includes tasks such as:

- Replacing defective or end-of-life bulbs or luminaries
- Replacing defective drivers and/or ballasts
- Cleaning fixture lenses/diffusers
- Replacing missing, damaged or yellowed lenses/diffusers as required
- In the case of LEDs that also function as part of main lighting, this may require calendar-based or condition-based change-out

For systems that utilize independent power sources, the railroad shall implement the recommendations established by the emergency lighting system manufacturer for periodic maintenance

For the main battery, this includes maintaining proper electrolyte levels, keeping battery clean, checking terminals and proper battery charger functioning, etc. The railroad will need to periodically replace batteries that have reached the end of their manufacturer's recommended service life.

Independent power sources typically are "maintenance-free," requiring only check of the status lights. The railroad will need to periodically replace batteries and/or supercapacitors that have reached the end of their manufacturer's recommended service life.

Battery maintenance and replacement intervals shall take into consideration the effect on battery life of cyclic charging and discharging of batteries that occur during operation and maintenance, as well as other factors that will affect the battery life.

5.1.2 Performance over time

Emergency lighting system performance on well-maintained equipment may diminish over time, as a combination of deterioration of the light output of fixtures as well as the main battery and/or independent power sources. This may require the railroad to periodically renew aging components with new ones in order to continue to keep the required light levels and durations of **Table 1** and **Table 2**.

5.1.3 Issues regarding light fixture light levels

Light fixture output may vary over time due to lamp characteristics, even with good maintenance. This section contains a discussion of different lamp types.

Incandescent and fluorescent lamps have an easily determined end of life and as such are routinely replaced as needed. Since the light level of these lamps does not vary significantly over their life, it can be assumed that the light output of the fixture remains constant over the life of the fixture. Likewise, fluorescent lamp ballasts perform properly until they fail, which again is easy to identify.

LEDs have a number of failure modes, making it more difficult to determine end of life:

1. LED fails to illuminate.
2. For matrix-type LEDs, some of the LEDs fail to light while others continue to perform properly. It is suggested that these be replaced when 70% or fewer of the matrix LEDs function.
3. LEDs dimming with age. This presents more of a problem, since it is difficult to judge the condition simply by looking at the device. LED technology is such that LEDs slowly get dimmer over time. The change in performance characteristic is identified by the LED chip manufacturer, generally stated as hours of service before the light intensity drops to 70% of original, say 50,000 hours. (A year is approximately 8,766 hours.) The use of LEDs in the car emergency light system varies greatly, such that in some applications these lamps are illuminated "all the time" and thus in perhaps 5½ years, light output of these LEDs will have dropped to the 70% value and it will be time to replace them. However, in some applications, the LEDs might come on only when normal power is lost and thus might never reach anywhere near 50,000 hours of service and would not need replacement over the life of the car lighting system.

The design of the car emergency lighting system employing LEDs needs to address how end of life will be addressed by the railroad in its maintenance practices. A variety of approaches may be taken, including but not limited to the following:

- Incorporate end-of-life function in the LED driver circuitry to annunciate when it is time to replace the unit.
- Routinely replace all car LED lamps on a calendar basis, based on anticipated hours of service. (Depending on the car design, perhaps a central timer could the clock hours the LEDs are illuminated.)
- Due to limited hours of illumination, the LED lamps may not reach the end of life.

For manual periodic regimes, analyze the duty cycle of the LED on and off times (LEDs that are minimally used, such as for emergency lighting, may never reach the end of lifetime replacement).

5.1.4 Issues regarding main battery deterioration

Typical nickel-cadmium and lead acid battery technology widely used today for car main batteries has the characteristic that the battery performance has a finite cycle life, resulting in the reduced ability to provide the rated ampere-hours as the battery ages. How rapidly this decline occurs is a complex subject, depending on many factors such as load, how often and how deeply the battery is discharged, as well as many other issues. The effect is that, as the battery ages, at some point in time it will no longer be able to support car emergency light loads for the required duration.

Railroads typically have a schedule for battery replacement for an entire fleet type (e.g., every 16 years), or possibly by conducting capacity tests to determine end of life. However, occasionally a battery fails or sustains damage requiring replacement at that time.

> **NOTE:** Section 6.1.4 applies only to cars in which the main battery is part of the standby/emergency light function.

5.1.5 Issues regarding IPS deterioration

The battery and/or supercapacitor technology typically used in independent power sources are subject to deterioration over time and cycling as follows.

5.1.5.1 Battery systems

The typical sealed-cell battery technology employed in an IPS has characteristics somewhat like that of the main battery, resulting in a loss of capacity over time. Often these IPS systems incorporate automatic or manually initiated self-discharge tests, which can be used to verify battery performance.

Railroads shall have a schedule for routine testing and replacement of these batteries, based on performance and/or on a calendar basis.

Batteries incorporating self-diagnostics or health monitoring can alert or confirm the authority of that battery's inability to perform compliantly. For any devices incorporating such active features, the replacement interval could be based upon the battery's diagnostic ability, a preventative maintenance test and/or the manufacturer's recommended replacement period.

For batteries without such active monitoring capabilities, the interval shall be based upon manufacturer-recommended testing and/or the manufacturer's recommended replacement period.

The battery-replacement interval shall be according to the IPS manufacturer's specifications, or if not specified, at least every five years.

5.1.5.2 Supercapacitor systems

The typical supercapacitor technology employed in independent power sources has characteristics somewhat like that of the main battery, resulting in loss of capacity over time.

Railroads shall conduct a functional test of the devices as part of the periodic inspection.

The replacement of these supercapacitors shall be based on their performance and/or on a calendar basis.

5.2 Periodic inspections and tests

5.2.1 Basic requirements

After the initial qualification test required by Section 3, railroads shall ensure that periodic tests to confirm the minimum illumination level and duration of the emergency lighting system are conducted no less frequently than once every eight years. This is a performance test conducted to verify that the car emergency lighting system has not deteriorated significantly below the initial performance. It is done on a statistical sample of cars. This test shall be conducted to demonstrate the system performance of the emergency lighting system from all applicable power sources.

If the emergency light system design does not change, and at the same time components are replaced with components with the same specifications, then the periodic testing of emergency lighting will not require reverification of minimum illumination levels. Refer to **Table 5** for details. If the emergency lighting system design does change, refer to **Table 4** for required testing.

For LED emergency lighting systems without end-of-life self-diagnostic functions, if the LED end of service life performance exceeds the minimum emergency lighting intensity requirements, then only a duration test need be performed as long as the OEM service life is maintained.

The railroad should provide justification for hours of service of LED emergency lighting operation used in developing the routine replacement of LED lamps. For fixtures incorporating end-of-life indicators, this is not required.

For LED emergency lighting systems with end-of-life diagnostic functions, illumination testing is not required.

TABLE 5
Measurements Required in Eight-Year Test if Car Has Not Been Modified Since Last Test

Light Source	Light Intensity Measurement	Duration Measurement
Incandescent	No	Yes
Fluorescent	No	Yes
LEDs "continuously on" replaced in kind at end of service life	No	Yes
LEDs used only for emergency lighting: still original	No	Yes
Original LEDs without end-of-life feature, if not replaced at end of service life	Yes	Yes
Original LEDs with end-of-life feature[1]	No	Yes

1. End-of-life feature indicates that it is time to replace the LED lamp at that fixture. It is assumed that the LED gets replaced when its life expectancy has been reached, and that the replacement has at least the light intensity as the original.

Incandescent and fluorescent lamps have an easily determined end of life and as such are routinely replaced as needed. LEDs dim with age, which makes it harder to determine end of life by simply looking to see if the lamp is illuminated.

5.2.2 Timing of tests

Table 6, **Table 7** and **Table 8** define the timing for conducting the eight-year cycle performance tests, as well as resets of the clock.

TABLE 6
Clock for Conducting Eight-Year Cycle Tests

Qualification Test Cycle	When Conducted
Initial full-car test	When car built, or new lighting system installed
First eight-year test	Eight years of in-service credit
Second eight-year test	Eight years from first test
Third eight-year test	Eight years from second test
Etc.	Eight years from previous test

TABLE 7
Conditions for Resetting the Eight-Year Clock

Category	Reset from Original Eight-Year Clock	Comments
No changes to car	No, continues eight years from last test	No changes to car
Changes made, partial car qualification test conducted for duration only	No, eight years from last eight-year test	No changes made affecting intensity
Changes made, partial car qualification test conducted for intensity	No, eight years from last eight-year test[1]	Changes made affected intensity
Full qualification test conducted	Yes, eight years from last qualification test	
Routine replacement of individual failed emergency light(s) as part of maintenance	No, continues eight years from last test	

1. If the unmodified portion of the car undergoes the eight-year test at the same time as the qualification testing on the modified portion of the car, then the clock is reset.

TABLE 8
Reset for Battery

Category	Reset from Original Eight-Year Clock	Comments
Original main battery	No, continues eight years from last test	Does not apply if main battery is not used for standby lighting
New[1] main battery	Yes, eight years from installation of new battery	Does not apply if main battery is not used for standby lighting
Original IPS power sources	No, continues eight years from last test	
New IPS power sources changed throughout car	Yes, eight years from installation of new IPS battery and/or capacitor(s)[2]	

1. "New" means new battery and/or IPS source was installed less than six months ago.
2. If the main battery is part of the emergency lighting system, the clock remains based on the original eight-year cycle.

5.3 Cars on which the testing is required

NOTE: Often, the performance of the emergency light test is undertaken after maintenance is completed to the car such as after COT&S or after a car overhaul when the car is ready to leave the shop and is in good condition to do the test.

5.3.1 Cars tested for light intensity

For cars tested for light intensity, a representative sample of cars or areas per ANSI/ASQC Z1.9-1993 shall be tested using the procedures in Appendix E or other statistically valid documented sampling method. If the first two randomly selected sample cars or areas exceed the illumination levels specified in **Table 1** and **Table 2** of this standard by a factor of four or greater, no further testing is required for the car or area represented by the sample car/area tested for the periodic test cycle.

For cars/areas with steady-state emergency lighting systems—that is, systems that do not dim gradually over the duration of the required illumination period—if the illumination levels exceed the initial required minimum levels by 40%, no further testing of illumination levels is required for the car or area represented by the sample car/area tested for the periodic test cycle.

5.3.2 Dating individual samples

Each contributing test of an individual sample is valid for eight years after the test is performed.

It is recognized that for large, dispersed fleets, there may be logistical challenges to conducting the periodic eight-year tests on the representative cars at exactly eight-year intervals. For this reason, the following guidelines are provided:

1. The goal of the selection process is to identify representative cars approaching multiples of eight years of service, so as to not test cars prematurely nor exceed eight years of service from the last test.
2. Age of fleet is defined as the calendar year the first car of the fleet was put into service.
3. If the fleet was delivered over several years, the first sample representative cars should be taken from the oldest cars, to the extent possible, of that fleet.
4. For the next iteration of the eight-year cycle, the first sample for that cycle should be taken no more than eight years from the date of the previous iteration. (For example, for a fleet delivered over the years from the beginning of 2000 through 2003, the first car should be selected from those delivered during 2000 and would be tested before the end of 2008. The next cycle of the eight-year test would begin in 2016 and also be from the cars delivered in 2000.)

5.4 Defect reporting, repair and recordkeeping

Defects, such as nonoperational emergency lighting fixtures, shall be reported and repaired in accordance with railroad procedures that comply with FRA (49 CFR Part 238) defect reporting procedures.

Recordkeeping shall be in accordance with railroad procedures that comply with FRA (49 CFR Part 238) recordkeeping procedures.

Railroads shall retain a copy of the test procedure describing the method used to obtain the measurement readings and a copy of the test data showing the illumination levels measured at the required locations (if required), and the results of such tests.

Railroads shall retain a copy of the test results until the next periodic test is conducted on a representative car/area, as required by this section, or until cars of that type are retired, transferred, leased or conveyed to another railroad. A copy of such records shall be transferred to the accepting railroad along with any such cars.

It is desirable for the railroad to retain older test results to allow it to watch for developing trends. Test data should be maintained for analysis regarding detrition.

Related APTA standards

APTA PR-E-RP-007-98, "Storage Batteries and Battery Compartments"
APTA PR-E-RP-012-99, "Normal Lighting System Design for Passenger Rail Equipment"
APTA PR-IM-S-001-98, "Passenger Rail Equipment Battery System Periodic Inspection and Maintenance"
APTA PR-IM-S-005-98, "Passenger Compartment Periodic Inspection and Maintenance"
APTA PR-IM-S-008-98, "Electrical Periodic Inspection and Maintenance of Passenger Coaches"
APTA PR-IM-S-013-99, "Passenger Car Periodic Inspection and Maintenance"
APTA PR-M-S-018-10, "Powered Exterior Side Door System Design for New Passenger Cars
APTA PR-PS-S-006-23, "Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment"

References

This standard shall be used in conjunction with the applicable sections of the following publications. When the following publications are superseded by a revision, the revision shall apply.

ANSI/ASQC Z1.9-1993, Sampling Procedures and Tables for Inspection by Variables.

49 CFR Part 238, Passenger Equipment Safety Standards.

49 CFR Part 239, Passenger Train Emergency Preparedness.

IEC 613373, Railway applications – Rolling stock equipment – Shock and vibration tests.

Definitions

action point: The position where a function or task is performed. Such functions may include, but are not limited to, activities such as reading a label or operating a release mechanism.

aisle: A path through a vehicle, which is not bordered by walls, such as down the center of a coach car that has a row of seats on each side.

auxiliary power system: An onboard source of electrical power (e.g., alternator/generator/car battery) typically used under normal operating conditions to supply such functions as lighting, air conditioning, etc.

car: A passenger-carrying rail vehicle.

color temperature: A numerical descriptor of the hue of a light source. It is expressed in terms of degrees on the Kelvin scale and refers to the temperature of a black-body radiator that produces light of the same hue as the source specified. Low color temperatures correspond to reddish sources, such as candle flames or incandescent lamps. Higher color temperatures are associated with cool-white fluorescent lamps, LEDs, blue sky and several types of new lighting technology.

diaphragm, conventional: A flexible enclosed walkway for the passage of passengers and crew between two adjacent cars, having two pieces, one located on the adjoining end of each car. These accommodate relative angular, lateral and vertical displacement between the ends of cars by means of sliding buffers at the floor level and by sliding faceplates with bellows or tubes sliding at the sides and top. This is typically employed on cars that get uncoupled.

foot-candle (fc): A unit of illuminance. One foot-candle is one lumen per square foot (lm/ft^2). In the international (SI) system, the unit of illuminance is lux (1 fc = 10.76 lx).

gangway: A flexible enclosed walkway for the passage of passengers and crew between two adjacent cars, employing a continuous bellows that is sufficiently flexible to accommodate relative angular, lateral and vertical displacement between car bodies. This is typically employed on semi-permanently coupled or articulated (angular motion only) cars.

head-end power (HEP): A system by which electrical power is provided to railroad vehicles from a central source via a trainline system. The source of power can be a locomotive or a power car. (Wayside supply from catenary, third rail or trackside can also be transformed into HEP as it passes through the power system.) HEP is used under normal operating conditions to provide electrical power to the passenger equipment systems, such as "normal" lighting. In the United States, 480 VAC, 60 Hz three-phase systems are most common.

illuminance: The amount of light falling on a unit of area (e.g., 1 ft^2 of surface). English units are foot-candles (fc) or lumens per square foot (lm/ft^2). International units (SI) are lumens per square meter (lm/m^2) or lux (lx). One fc equals 10.76 lx.

independent power source: A sealed battery or other energy storage device located within the car body that is designed to power one or more emergency light fixtures or other devices within the same car when the normal HEP, main car battery, auxiliary power and/or wayside power are unavailable.

lighting, emergency: Lighting mode that is activated when power for the normal lighting and standby lighting (if equipped) becomes unavailable in a car. Two or more independent power sources within the same car, aside from the main car battery, are used to supply the power to operate the fixtures that provide emergency lighting in each car.

lighting, emergency (former definition): Lighting mode that is available whenever power for the normal lighting is unavailable. The main car battery or one or more independent power sources can be used to supply the power to operate the fixtures that provide emergency lighting.

lighting, normal: Lighting mode that is available when the car is in operation with the normal power system.

lighting, standby: Lighting mode that is available (if so designed) when the car loses normal power, but the main car battery has not yet discharged to load shed (see also *load shed* and *power, standby*).

load shed: An electrical power system design in which some of the main car battery load is disconnected partway through the discharge cycle so that the remaining battery capacity can be used exclusively to provide power to the most important loads, e.g., a portion of normal lighting, emergency lighting and PA system. The effect is to considerably extend the length of time these critical loads can be supported. The approach may include disconnecting such items as door operators, controls and some of the lighting from the main battery power source.

lumen: The international unit of luminous flux or the time rate of flow of light.

luminaire (light fixture): A device to produce, control and distribute light. A complete unit typically consists of one or more lamps, sockets to hold and protect the lamps, optical devices to direct the light, and circuitry to provide the required electric power to the lamp(s).

main level: A level of a passenger car that contains a passenger compartment whose length is equal to or greater than half the length of the car.

main car battery: A battery or set of batteries used to provide power to a car or trainset in case of loss of normal power during normal operations.

passageways: A path directly bordered by walls that allows a passenger or crew member to move from one location to another.

power, standby: Power mode that is available (if so designed) when the car loses normal power, but the main car battery has not yet discharged to load shed. This mode is intended to keep a substantial number of the normal lighting fixtures, including those normal lighting fixtures also used as emergency lighting fixtures, operating for a short period (90 seconds to 30 minutes or more) so that short term power outages, such as those that occur when adding cars or changing locomotives at the station, will have only a minor effect on passengers. This type of lighting power is used primarily on newer intercity passenger cars.

representative car/rea: A car/area that shares the relevant characteristics as the car(s)/area(s) it represents (i.e., same emergency lighting fixtures, system layout and power system).

room/compartment: A space that can be occupied by passengers or crew, which is enclosed on at least three and usually all four sides.

spatial average: The average of all samples taken in the vicinity of a specific location. The area of a spatial average varies. For a stairway, it includes only the area of the stair step(s). For an aisle, the entire length of the aisle is included.

stairway: Continuous set of steps (not interrupted by a landing).

stanchion: An upright bar, post, or support.

threshold: A raised metal strip, located below and parallel to a door when in the closed position, that marks the boundary between the areas the door divides.

vestibule: An area of a passenger car that normally does not contain seating and is used in passing from the seating area to the side exit doors.

Abbreviations and acronyms

CFR	Code of Federal Regulations
CIE	Commission Internationale de l’Eclairage (International Commission on Illumination)
cm	centimeters
COT&S	cleaned, oiled, tested and stenciled
EL	Electroluminescent
fc	foot-candle
FRA	Federal Railroad Administration
HEP	head-end power
IPS	independent power source
LAN	local area network
LED	light emitting diode
lm	lumen
lx	lux
m	meter
MU	multiple unit
OEM	original equipment manufacturer
PA	public address

PRESS	Passenger Rail Equipment Safety Standards
NTSB	National Transportation Safety Board
SI	Système International
UL	Underwriters' Laboratories

Summary of document changes

- Document formatted to the new APTA standard format.
- Sections have been moved and renumbered.
- Scope and summary moved to the front page.
- Definitions, abbreviations and acronyms moved to the rear of the document.
- Two new sections added: "Summary of document changes" and "Document history."
- Some global changes to section headings and numberings resulted when sections dealing with references and acronyms were moved to the end of the document, along with other cosmetic changes, such as capitalization, punctuation, spelling, grammar and general flow of text.
- Names of participants updated.
- Addition of independent power source (IPS), normal lighting, and standby lighting to keywords section.
- Summary and Scope and Purpose sections updated to provide succinct information regarding the contents of the standard. References to companion documents in these sections removed. Much of the removed material relocated to the Introduction section.
- Introduction updated. Added reference to APTA PR-E-RP-012-99, "Normal Lighting System Design for Passenger Rail Equipment."
- Section 1.1: Added the full spelling of head end power in addition to the already present acronym. The word "power" added after auxiliary in second sentence. Temporal clarifications regarding trends in power supplies for normal lighting systems. 28 VAC removed and 24 VDC added as typical normal lighting power voltages.
- Sections 1.2 and 1.3: order reversed.
- Section 1.2: Clarified the activation criteria for emergency power. Removed typical emergency lighting approaches. Added reference to minimum duration, location, and power source requirements for emergency lighting. Added new date requirement for location of independent power sources. Changed new requirement on power source location from previous revision into note. Added automatic testing requirement for supercapacitors used as independent power sources.
- Section 1.3: Removed functional description of standby power as it out of the scope of this document. Highlighted that only certain older equipment can use standby lighting to fulfill the duration requirement. Delineated the boundary between standby power and emergency power. Added note regarding standby power intended for use will during normal operations such as phase breaks and third rail gaps.
- Section 2.1: Term toilets replaced with restrooms.
- Tables 1 and 2: Table 1 from previous revision split into two separate tables, the new table 1 detailing the areas measured, where the measurement is taken and under what conditions the measurement is performed and the new table 2 detailing intensity, duration, power source, and power source placement requirements.
- Table 1: changes detailed individually in subsequent sections.
- Table 2: requirements affected by incorporation by reference in the CFR added. New Independent power source location requirements added for new equipment.
- Section 2.3: Section retitled. An application date is provided for equipment for which standby power was ambiguous as to whether it could fulfill emergency lighting requirements in previous revision. Starting point for emergency lighting duration requirement specified.
- Section 3.1: Qualification test (initial verification) section and subsections added.
- Section 3.3: Preparation for tests section split into subsections and clarified.

- Section 3.4: additional data collection information added to reflect current practices.
- Section 3.5.1: added rationale for floor measurement value exception.
- Section 3.5.2: added separate testing of standby power for certain equipment. Added final measurement exception for constant power emergency lights.
- Section 3.5.3.2: changed to individual measurement separation maximum from average of 20. Added door conditions. Added equal spacing requirement.
- Added sections detailing requirements for each location specified in table 1.
- Section 3.5.3.8: Changed requirements for end frame door measurement conditions and location.
- Section 3.5.3.9: added section on inter-car passageways (diaphragms and gangways).
- Section 3.5.3.11: New requirements for cab measurement conditions.
- Section 3.6: Retesting emergency lighting section added.
- Section 5: added note on deep discharge considerations.
- Section 6: removed references to Inspection and Maintenance standards.
- Section 6.1.1 through Section 6.2.2: added new sections replacing previous content.
- Section 6.3: New section on testing individual sample collection for representative sample cars.
- Section 6.4: added retention of test procedure and results requirements.
- Definitions: added definitions for diaphragm, conventional, gangway, main car battery, stanchion, and threshold. Added new definition for emergency lighting, labeling previous definition former. Removed entrance/exit.
- Added new acronyms.
- Added Appendix C.4.
- Replaced sample data sheet.
- Appendix E: created allowance for use of special inspection levels (S3) to be used in lieu of General II.
- Appendix E.1.2 added.
- Appendix F added.

Document history

Document Version	Working Group Vote	Public Comment/ Technical Oversight	Rail CEO Approval	Policy & Planning Approval	Publish Date
First published	—	—	—	March 4, 1999	March 17, 1999
First revision	—	—	Sept. 11, 2007	Oct. 7, 2007	Oct. 22, 2007
Second revision	Sept 8, 2022	Nov. 30, 2022	March 6, 2023	June 6, 2023	June 6, 2023

Appendix A (informative): Bibliography

[B1] AAR Manual of Standards and Recommended Practices, Section A-Part III, Section 26, Emergency Lighting, Revised 1984.

[B2] Demaree, J. "Examination of Aircraft Interior Emergency Lighting in a Postcrash Fire Environment." Federal Aviation Administration, FAA Technical Center, Final Report. No. FAA-DOT/FAA/ct-82/55.

[B3] FAA 14 CFR, Part 25, Airworthiness Standards, Transport Category Airplanes, Subpart D, Design and Construction, Subsection 25.812, Emergency Lighting.

[B4] FAA 14 CFR, Part 121, Operating Requirements, Domestic, Flag, and Supplemental Operations, Subpart K, Instrument and Equipment Requirements, Subsection 121.310, Additional Emergency Equipment.

[B5] FAA Advisory Circular 20-38A. Measurement of Cabin Interior Emergency Illumination, February 1966.

[B6] Illuminating Engineering Society (IES). Lighting Handbook, Reference and Application, Chapter 29, 9th edition, 2000.

[B7] National Fire Protection Association NFPA 70, National Electrical Code, 2006. Quincy, MA. 2006.

[B8] NFPA 101, Life Safety Code, Chapter 7, Means of Egress. 2006.

[B9] NFPA 130, Fixed Guideway and Passenger Rail Systems, NFPA, Quincy, MA, 2006.

[B10] UL 924, Standard for Emergency Lighting and Power Equipment, 9th edition, dated Feb. 24, 2006. Effective Date, Aug. 24, 2006.

[B11] National Transportation Safety Board (NTSB). Collision and Derailment of a Maryland Rail Commuter MARC Train 286 and National Railroad Passenger Railroad (Amtrak) Train 29 Near Silver Spring, Maryland on Feb. 16, 1996. Report No. NTSB/RAR-97/02. Adopted July 3, 1997.

Appendix B (informative): Automatic testing of electrically powered lighting systems that use batteries as independent power sources

Emergency lighting systems using independent power sources have important advantages since they are not vulnerable to loss of the main car battery power supply and/or damage to the main car battery power supply wiring. However, for the independent power supply to the emergency lighting system to be reliable and operate when necessary, multiple individual batteries must be periodically tested for each rail car (for cars with only two such batteries, each one must be tested). Batteries that are used as independent power sources shall have automatic self-diagnostic modules designed to perform discharge tests upon demand by maintenance personnel.

Manual testing requires that a worker first determine that all independent power sources using batteries have been connected to a source of charging power for the necessary amount of time to reach full charge. Then, car by car, the charging power must be disconnected and the emergency lighting system switched into emergency mode. After the prescribed 60- or 90-minute time period for discharge, the worker must then revisit each car and note which emergency light fixtures are working properly and which are not. While such tests are in progress, some kinds of maintenance work are effectively precluded by the lack of light inside the car.

Self-test modules display the results of the most recent test by means of a multicolor LED on the light fixture. For a typical fixture, the LED can indicate any of the following conditions:

CONDITION	STATUS INDICATION
Normal mode	Steady green
Self-testing	Flashing green
Emergency mode	Off
Insufficient charge	Flashing red/green
Battery pack failure	Single-flash red
Emergency lamp failure	Double-flash red
Self-diagnostic module failure	Triple-flash red
Under/over charge	Quadruple-flash red

The status indication remains displayed until the next scheduled periodic test or until a repair is performed. Only a momentary observation is required to see that a unit is functioning normally. Only failed components require action by maintenance staff.

Automatic testing offers the important advantage of allowing one worker to determine the condition of every emergency light fixture in the time it takes to walk the length of an entire train and requires no special preparation. In addition, it is not necessary to turn off normal lighting, so there is no interference with other inspection and maintenance activities.

Appendix C (informative): Data collection guidance

C.1 Equipment

There are at least three handheld meters on the market with adequate accuracy and sensitivity for this application. These meters are listed below and illustrated in **Figure 1**:

- Minolta T-10A Illuminance meter and cable
- Gigahertz-Optik X1 with VL 3704 illuminance detector
- Hagner E4-X digital luxmeter

Other meters that meet the performance specifications listed in Section 3 are also acceptable.

Illuminance sensors may need recalibration if the meter is dropped. Special care is required to avoid this. Gigahertz-Optik offers an optional foam rubber shock protector for its sensor.

Railroads with fleets consisting entirely of brightly illuminated cars may forgo the use of a meter with precise off-axis response, because high levels of floor illumination can be used to establish that illumination on vertical surfaces is adequate for door control signs/markings. Low-cost meters that conform to CNS 5119, Class II (which permits unlimited errors for angles of incidence greater than 60 deg.) may be used for floor and armrest level measurements of illumination. Because field data have shown that illuminance values on vertical surfaces are at least 20% of the illuminance on adjacent floors, the floor measurements made with inexpensive meters can be used to demonstrate compliance with this standard whenever the values at the floor are five times greater than required illuminance on the surface of the exit door/control sign/marking in question. Meters for this application are widely available from vendors such as Extech, TES, Tenmars, etc.

> **NOTE:** CNS 5119 is a standard developed in Taiwan. It is available for viewing in Mandarin at: http://www.cnsonline.com.tw/en/.

Other considerations: The Minolta can be set to readout in foot-candles or lux; the Gigahertz-Optik meter may be ordered with either foot-candle or lux displayed; while the Hagner meters read out in lux only. The Minolta and Gigahertz-Optik meters have USB data outputs. The Hagner meter has an analog data output and requires an external USB data-acquisition adapter. The Minolta meter has a detachable head that can be connected to the meter body with ordinary LAN cable of 6.5 ft (2 m) provided that the optional A20 and A21 adapters are purchased. The other meters have 6.5 ft (2 m) cables permanently attached to the sensor.

C.2 Timing of readings

Readings should be taken at least 15 minutes after the normal illumination charging light is placed in operation to allow the lamps to reach full output and per Section 3.

FIGURE 1
Typical Meters for Illuminance Measurements

C.3 Computer data collection

The measurements required by Section 3 must be performed by manually placing the light sensor at the designated locations. However, the numerous aisle measurement readings to determine the minimum average illumination levels required in **Table 1** can be taken much faster and more accurately using a computer. The computer data collection technique is based on moving/dragging a sensor down the aisle at a slow, steady pace while readings are captured to a notebook computer or data logger at the rate of at least one reading per second.

To collect data representative of illumination levels at armrest height, an apparatus must be constructed to support the sensor at a height of 25 in. (64 cm) above the floor and to carry the meter electronics and computer/data logger. **Figure 2** shows such an apparatus, built from an ordinary luggage cart, with a bracket to support the sensor. The bracket, meter and computer are held in place with hook-and-loop self-adhesive tape. A 6 ft (2 m) towline is used to pull the cart to keep the observer's shadow from affecting readings.

The average is calculated with spreadsheet software based on 60 or more samples—i.e., the data collector should walk at the rate of about one foot per second. The software will also find the minimum value in each set of readings and may be used to generate a graphic profile of illuminance levels along the length of the car.

The minimum test period duration is either 90 or 60 minutes, per Section 3. All illuminance light levels are measured and recorded immediately at the start of the test and again at the end of the final time duration.

FIGURE 2
Apparatus for Measuring Average Illuminance Levels

Consists of a handheld illuminance meter with sensor, an analog-to-digital converter (if not built into the meter), a notebook computer, a luggage cart with an added bracket to hold the sensor, an extra caster and a towline.

C.4 Sample data recording sheet

Figure 3 is a generic sample of a data sheet to be used to record the results of emergency light performance tests. Each railroad will need to review the content and adjust it according to the specific needs of their rolling stock.

FIGURE 3

Sample Data Sheet for Emergency Light Performance Test

Test Type	□ Qualification □ Periodic □ Other (explain)
Date of Test	
Car Number	
Car Builder	
Car Series (M1, M2, etc.)	
Car Type (coach, cab car, etc.)	
Facility Where Conducted (Geographic location and facility)	
Test Conducted By	
Test Witnessed By	
Time of Day Test Started	
Car Interior Temperature (est.)	
Car Exterior Temperature (est.)	
Main Battery Capacity A-H (if applicable)	
Main Battery Installation Date (if applicable)	
Renewal of LED Fixtures Date (as applicable)	
Renewal of IPS Power Sources Date (as applicable)	
Renewal of Fluorescent Lamps (if applicable)	
Other comments	

Instruments Used				
#	**Test Instrument**	**MFG Model**	**Serial #**	**Calibration Due Date**
1.				
2.				
3.				
4.				
5.				
6.				
7.				

FIGURE 3

Sample Data Sheet for Emergency Light Performance Test

Duration-Only Test				
	Start	**Finish**	**Duration**	**Comments**
Standby Lighting				
Emergency Lighting				

Light Intensity Readings						
Start Time for Series of Measurements (HH:MM):						
#	**Text Ref.**	**Location of Reading**	**Initial Reading**		**Final Reading (60 or 90 minutes)**	
			Left or A-End	**Right or B-End**	**Left or A-End**	**Right or B-End**
1	**3.5.3.1**	**Door emergency exit controls/manual releases-1**				
2		**-2**				
3		**-3**				
4	**3.5.3.2**	**Aisle-1**				
5		**-2**				
6		**-3**				
7		**-4**				
8		**-5**				
9		**-6**				
10		**-7**				
11		**-8**				
12		**-9**				
13		**-10**				
14		**-11**				
15		**-12**				
16		**-13**				
17		**-14**				
18		**-15**				
19		**-16**				
20		**-17**				
21		**-18**				
22		**-19**				
23		**-20**				
24		**Spatial average 1–20**				

FIGURE 3

Sample Data Sheet for Emergency Light Performance Test

#	Text Refer.	Location of Reading	Initial Reading		Final Reading (60 or 90 minutes)	
			Left or A-End	Right or B-End	Left or A-End	Right or B-End
25	3.5.3.2	Passageway-1				
26		-2				
27		-3				
28		-4				
29		Spatial average 1–4				
30	3.5.3.3	Stairway, top				
31		Stairway, middle				
32		Stairway, lower				
33		Spatial average				
34	3.5.3.4	Passage door threshold inside				
35		Passage door threshold outside				
36	3.5.3.4	Vestibule door threshold, inside-A				
37		Vestibule door threshold, outside-A				
38		Vestibule door threshold, inside-B				
39		Vestibule door threshold, outside-B				
40	3.5.3.5	Exterior side door threshold				
41		-Trap closed, door closed-L				
42		-Trap closed, door open-L				
43		-Trap open, door open-L				
44		-Trap open, door closed-L				
45		-Trap closed, door closed-R				
46		-Trap closed, door open-R				
47		-Trap open, door open-R				
48		-Trap open, door closed-R				
49	3.5.3.7	Vestibule steps				
50		-Top step-L				
51		-Bottom step-L				
52		-Average-L				
53		-Top step-R				
54		-Bottom step-R				
55		-Average-R				

FIGURE 3

Sample Data Sheet for Emergency Light Performance Test

#	Text Refer.	Location of Reading	Initial Reading		Final Reading (60 or 90 minutes)	
			Left or A-End	Right or B-End	Left or A-End	Right or B-End
56	3.5.3.8	End frame door threshold inside				
57		End frame door threshold outside				
58	3.5.3.9	Diaphragm/gangway				
59	3.5.3.10	Restroom area				
60		Restroom: ADA -1				
61		-2				
62		-3				
63		Spatial average				
64	3.5.3.11	Crew area of MU or cab car				
65		-Door exist path				
66		-Stair step				
67	3.5.3.12	Galley/cafe behind counter-1				
68		-2				
69		-3				
70		-4				
71	3.5.3.13	Sleeping car rooms (each room separately)				
72						
73						
74						
75	3.5.3.14	Other specialty areas				
76						
77						
78						
79		Additional areas as needed				
80						

Appendix D (Informative): Alternatives to increase illumination levels

If, during the interior verification tests or periodic inspections, the level of the illuminance of normal or emergency light fixtures fails to meet the minimum illuminance criteria, as measured directly on the floor or other action point surface, there are several actions that can be taken to increase the illumination levels:

- Check the battery voltage.
- Check the light fixtures near the test areas to ensure proper working order.
- Clean light fixtures and check to ensure that the diffusers are not yellowed with age. Old, dirty fixtures have been measured with less than half the light output of clean ones with new diffusers.
- Check fluorescent lamps to ensure they are not near the ends of their service lives, when light output drops significantly.
- Replace warm-white fluorescent lamps with cool-white fluorescent lamps.
- Replace incandescent luminaires with fluorescent lamps or LED luminaires.
- Replace existing fluorescent lamps with those of recent design that provide 10% to 15% more light for the same wattage rating and double the service life.

Appendix E (informative): Representative sample sizes, periodic maintenance

E.1 Representative sample sizes

E.1.1 ANSI/ASQ

The American National Standards Institute (ANSI) and the American Society for Quality (ASQ) have developed detailed procedures for determining representative sampling plans for maintenance inspection operations. These may be found in "Sampling Procedures and Tables for Inspection by Variables for Percent Nonconforming" (ANSI/ASQC Z1.9-2003). In Section A7.1 of this standard, various inspection levels, which allow for alternative sample sizes, are explained. When operations do not permit the preferred inspection level of "General II" to be carried out, "Special Inspection Levels" (S3) may be used. If the total car fleet is smaller than the number of samples required by ANSI/ASQC Z1.9-2003, then the sample size is equal to the car fleet size.

In determining whether to accept or reject the fleet's emergency light performance, the methods of Section B, Form 2, should be used, since variability of the fleet, or "lot," is unknown. Additionally, a quality acceptance limit of not more than 2.5% shall be used, per industry practices.

If the first sample has acceptable results, as defined by ANSI/ASQC Z1.9-2003, no further action is needed. If the sample fails, a new sample should be tested using "tightened" inspection procedures. If the new sample passes, document and correct any single car/area that failed to meet the criteria of Table 1, Section 6, of this standard. After completion of the repair, no further action is needed. If the second sample fails, determine the cause, document, and implement a fleet-wide redesign/repair to correct the defect. Upon completion of repairs, reinspect using tightened inspection procedures.

Areas of similarity within a vehicle do not require additional testing.

E.1.2 Determining fleet size for sampling purposes

Cars of different manufacturers or different marking/signage designs cannot be considered as part of the same fleet when considering sampling for periodic testing.

Justification shall be provided if a railroad elects to include similar yet different rolling stock within the same fleet for sampling purposes. Examples of this include, but are not limited to, the following:

- cab cars, trailer cars, power cars, MUs and cab cars running as trailer cars
- different car orders
- identical areas across multiple variants of the same base design

Justification for the inclusion of similar yet different rolling stock within the same fleet for sampling purposes shall include either numerical or logical proof that the inclusion of the similar yet different cars shall not create a false positive sampling for any of the sub-fleets included. If sub-fleets are included within the same sample set, at least one sample from each sub-fleet shall be included within the sample set.

Appendix F: Test procedures (normative)

F.1 Overview

The test shall be conducted to demonstrate the system performance of emergency lighting system from each power source, including main battery and/or independent power sources.

Table 5 is used to establish which testing scenario is required: duration only, or intensity and duration.

For cars requiring intensity testing, the procedure followed should comply with the requirements of Section 3.5, "Procedures for measuring illuminance of emergency lighting systems."

F.2 Test procedure

A detailed step-by-step test procedure is required to conduct the lighting test. It should include, at a minimum:

1. Purpose (periodic eight-year, etc.) including identifying which scenario applies
2. Equipment on which it will be conducted (typically car number series)
3. Any references required, such as drawings, etc. (lighting arrangement drawing)
4. Prerequisites for the test (identifying the state of the car to be tested: battery condition, IPS condition, light fixture lenses clean, new lamps, etc.)
5. Test equipment to be employed (light meter, multimeter, etc.)
6. Initial conditions required (only for intensity test, include sketch identifying exact site of each measurement)
7. Step-by-step procedure for taking the measurements
8. Data sheet to record readings (refer to **Figure 3**)
9. Final conclusion with signatures of those conducting/witnessing the test

F.3 Test sequences for duration tests (including those requiring intensity readings)

Emergency lighting system design can take three forms, as indicated below. The sequence of events in the duration tests should follow as indicated.

Emergency lighting provided solely by independent power sources (no power from main battery)

1. Establish initial conditions.
2. Trigger emergency lighting by shutting off HEP/auxiliary power.
3. Measure time duration lighting system remains on.

Emergency lighting provided solely from main battery (standby lighting)

1. Establish initial conditions.
2. Trigger emergency lighting by shutting off HEP/auxiliary power.
3. Measure time duration lighting system remains on.

Combination, with standby lighting provided from main battery, followed by emergency lighting provided from independent power sources

1. Establish initial conditions.
2. Trigger emergency lighting by shutting off HEP/auxiliary power.
3. Conduct test of standby emergency lighting, followed by IPS-powered lighting.
4. Measure time duration standby lighting system remains on.
5. Verify that IPS is triggered on after standby system shuts down.
6. Measure time duration emergency lighting system remains on.

If light intensity testing is required employing the main battery, Section 3.2, "Battery emulation," may be used.

F.4 Preparation for tests

F.4.1 Car preparation

The car to be tested is to be in a condition suitable to conduct the test accurately under known, reproducible conditions.

Functional test

1. Activate the emergency lighting system and verify that all the required lights are illuminated and are functioning normally. For cars employing both main battery standby and IPS emergency lighting, both systems must be tested. Verify that the scheme used to trigger emergency lighting functions correctly, especially on equipment employing both main battery and IPS sources.
2. Verify that none of the emergency lighting components have fault indications illuminated (including but not limited to "end-of-life").
3. Correct any problems identified.

F.4.2 Initial conditions

Battery system

1. Information should be recorded identifying date of manufacture and time in service of main and independent power source batteries (if available).

Main battery

1. Main battery should be clean; for any wet batteries, fluid levels should be topped up as required.
2. Battery should be fully charged, as identified by the manufacturer.

Independent power sources

1. These should be fully charged, as identified by the manufacturer.

Temperature

1. Lighting is temperature sensitive; car interior should be nominally 70 °F or above.
2. In addition, the car lighting system should be under power for at least 15 minutes before the test is started to warm up fixtures to the temperature they would experience in normal operation.

The following two items apply only to cars undergoing intensity and duration testing:

Light fixtures

1. Lenses must all be in place and clean.
2. Incandescent and fluorescent lamps should be new; the latter should be aged for at least 100 hours before to ensure they achieve full light level.

Car interior

1. The car should be free of trash and tools.
2. Protective wall and floor coverings that could influence readings must be removed.
3. The car should be configured and equipped as it would be when ready for revenue service.

F.4.3 Darkening the car and car setup

The car shall be configured as indicated before beginning the light level measurements. The intent is to configure the car in test to simulate it being disabled in a dark area on a clear, moonless night. The car should be arranged to depict it as it would be in typical revenue service. In addition, the individual reading locations are intended to be areas of interest to a passenger attempting to exit the area. For example, finding the emergency release instructions is relevant only if the door is closed. For further details, refer to Section 3.3.

F.4.4 Mark locations where readings will be taken

1. To expedite taking readings, the site of each required reading should be marked on the car, such as through the use of masking tape or stickers. It is helpful to number each site.
2. For the 25 in. height, a small stand should be created upon which to place the light sensor.
3. For semipermanently coupled trainsets, the testing of the semipermanently connected areas must be addressed in the test plan.

F.4.5 Configure car power system for test

1. All the battery loads that may be applied under emergency conditions shall be identified. Circuit breakers shall be set so that those loads (door operators, PA system, controls, headlights or marker lights, etc.) that are normally present in revenue service are energized during the emergency lighting tests.
2. The tests shall be conducted with main battery power and/or IPS only; any feeds from HEP, auxiliary or wayside sources shall be disconnected.

F.5 Data collection

When testing the emergency lighting performance of a car, a record shall be taken of the condition of the car and the method of making the test. As a minimum, this information shall include the following:

1. Number of car
2. Car type (e.g., Superliner-1 Sleeper)
3. Location where test is conducted: geographic location and where (e.g., in car wash building in Amtrak 14th Street shops, Chicago)
4. Year car put into service (identify grandfathering, as applicable)
5. Identification of individual(s) conducting test
6. Dates test conducted
7. Time of day
8. Record the status of the following:
   - Last renewal of main battery as required by authority maintenance policy (if available)
   - Last renewal of LED light fixtures as required by authority maintenance policy (if available)
   - Last renewal of IPS power sources (battery and/or supercapacitor) as required by authority maintenance policy (if available)
   - Last renewal of fluorescent and/or incandescent lamps as required by authority maintenance policy (if available)

   NOTE: These record are desirable to allow the railroad to better understand trends of components versus their age.

9. Record the instruments used:
   - Manufacturer and model number
   - Serial number of instrument
   - Date of last calibration
   - Whether equipped with color correction filter
10. Car interior air temperature
11. Outside ambient temperature

12. Method of darkening the car (photos may be used as reference)
13. Start, end and duration times for standby (if equipped) and emergency.

    NOTE: Standby mode does not have a mandatory duration requirement

14. Location of readings (need an illustration to show this; could be lighting arrangement drawing)
15. Light intensities (required only for cars undergoing intensity and duration test)

This information must be included with the test procedure documentation. A copy of such documentation is an acceptable record.

Appendix C contains a data sheet form suitable for recording all the above information.

APTA STANDARDS DEVELOPMENT PROGRAM
STANDARD
American Public Transportation Association
1300 I Street, NW, Suite 1200 East, Washington, DC 20005

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PRESS Mechanical Working Group

Code of Tests for Passenger Car Equipment Using Single Car Testing

Abstract: This document establishes a standard for the testing of a single passenger car equipped with 26-C and newer style brake equipment.

Keywords: single car test device, single car test, 26-C, Brake Test

Summary: This standard provides a means by which passenger car brake equipment can be tested before being entered into service. The practices outlined herein may be modified by the equipment manufacturer/operating authority as long as the original intent of the publication has been maintained. All modifications to this publication may be subject to inspection to ensure that the equipment is tested properly.

Scope and purpose: Revision 4 of this Standard shall be used after March 1st, 2019, for testing 26-C or equivalent type brake equipment. The Single Car Test Device and test racks may need to be modified to meet these requirements. All equipment shall be tested at the same brake pipe pressure used in service operation. The purpose of this standard is to describe the test procedures by which a general check on the condition of passenger brake equipment on cars can be made. It covers cars while in service and cars having undergone "periodic repairs." The Single Car Testing Device enables this testing to be accomplished without removal of any components from the car. The latest revision of this standard shall be available at the location where testing is performed.

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Introduction

This introduction is not part of APTA PR-M-S-005-98, Rev. 4, "Code of Tests for Passenger Car Equipment Using Single Car Testing."

This standard applies to all:

- Railroads that operate intercity or commuter passenger train service on the general railroad system of transportation; and
- Railroads that provide commuter or other short-haul rail passenger train service in a metropolitan or suburban area, including public authorities operating passenger train service.

This standard does not apply to:

- Rapid transit operations in an urban area that are not connected to the general railroad system of transportation;
- Tourist, scenic, historic, or excursion operations, whether on or off the general railroad system of transportation;
- Operation of private cars, including business/office cars and circus trains unless otherwise required by other standards or regulations; or
- Railroads that operate only on track inside an installation that is not part of the general railroad system of transportation.

NOTE: For this standard, pressures associated with 110 psi operation are shown first in **BOLD**, followed by the corresponding pressure used with 90 psi service. Example: **110 psi** (90 psi).

Code of Tests for Passenger Car Equipment Using Single Car Testing

1. Electronic Air Brake Systems

1.1 Electronic Air Brake (EAB) systems refer to microprocessor based electronic service brake control of brake cylinder pressure.

1.2 EAB systems may employ self-test features and/or runtime diagnostics that validate functions. If self-test features are used to validate the system, then the operator shall provide a matrix identifying which sections of PR-M-S-005-98 are addressed by the application of the self-test function. Justification for self-test validation equivalence shall be provided.

1.2.1 Electronic record of successful self-test results shall be available for inclusion in the overall car test record.

1.3 Cars equipped with EAB control systems shall be tested in both normal and backup modes. Functions not influenced by the powered state of the brake system require testing in only one state (normal or back-up) for validation.

1.3.1 Normal mode is defined as the EAB system being powered and active with microprocessors controlling and monitoring the functionality of the system.

1.3.2 Back-up mode is defined as the EAB system in an un-powered state with only pneumatic functionalities.

2. Single Car Testing Device and Bleed Cock Arrangement

> **NOTE:** The Single Car Testing Device used shall conform to the requirements of this standard. The Device shall be equipped with a FLOWRATOR, reducing valve and strainer.

> **NOTE:** When testing equipment at 110 psi brake pipe pressure, the Single Car Testing Device shall be equipped for 110 psi operation. A kit for upgrading a Single Car Test Device can be acquired from the Single Car Testing Device manufacturer.

2.1 General Description

There are two types of the Single Car Testing Device, which are similar in appearance. One is for passenger cars and the other for freight cars. The Devices are identified by nameplates, which are marked “SPFRS” for a passenger Single Car Testing Device or “SFFRS” for a freight Single Car Testing Device. It is required to use the correct Single Car Testing Device for the type of brake equipment being tested.

Throughout this standard, the Single Car Testing Device shall be referred to as the “Device.” The Device is shown in **Figure 1**. Detail of the Single Car Testing Device Test Coupling is shown in **Figure 2**. The Rotary Valve and Rotary Valve Seat are shown in **Figure 3**.

FIGURE 1

Standard Passenger Single Car Testing Device with FLOWRATOR (SPFRS Designation)

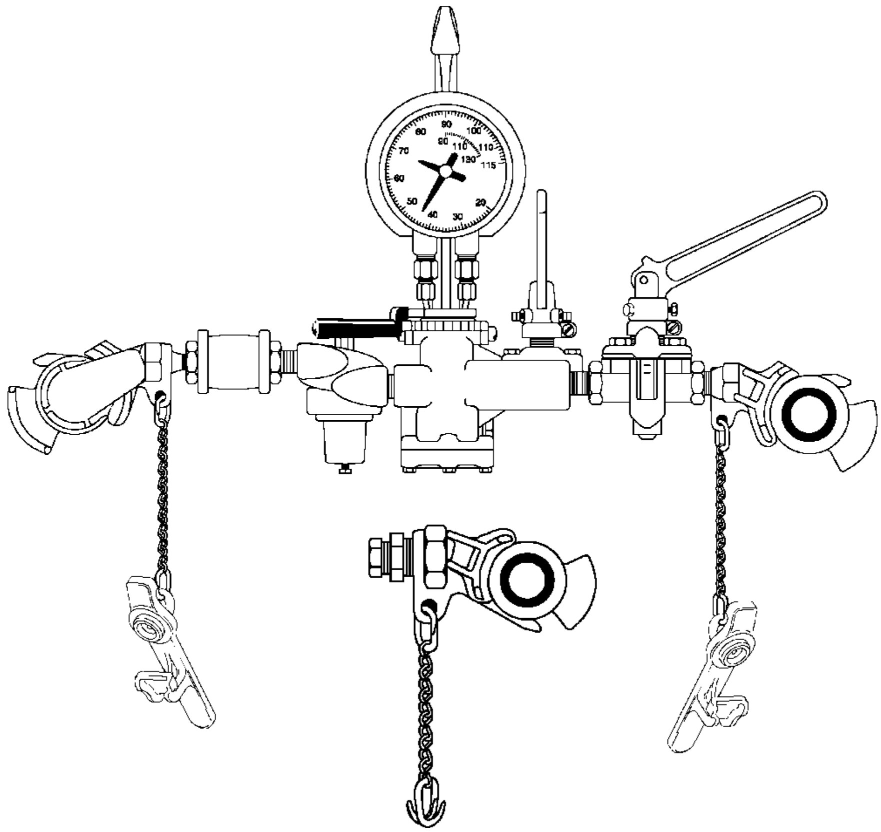


FIGURE 2

Single Car Testing Device Test Coupling (Passenger) (Part of Device)

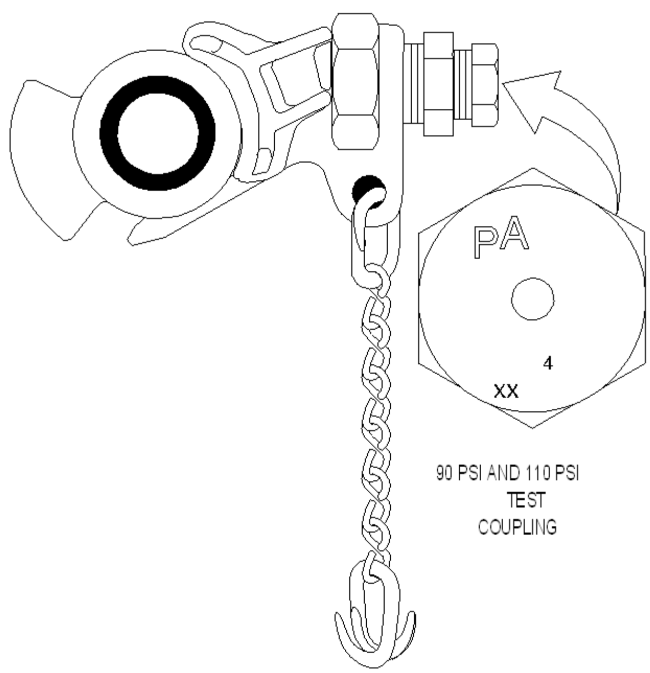
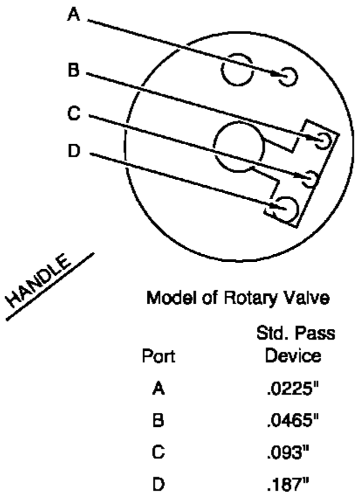
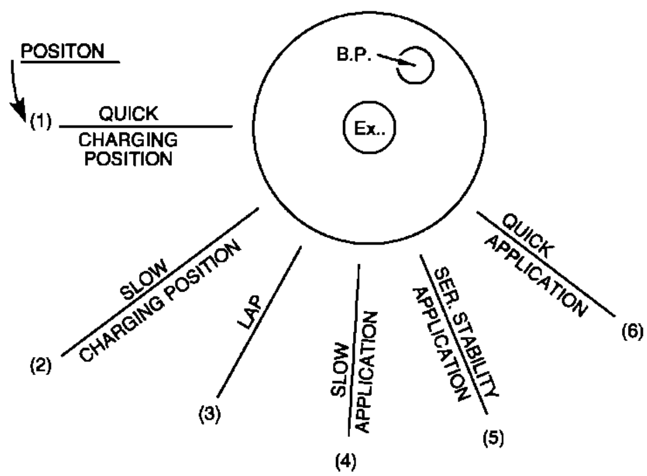


FIGURE 3
Rotary Valve and the Rotary Valve Seat of the Single Car Testing Device

Positions of Standard Passenger Single Car Testing Device	
Position No. 1	MR charges brake pipe through 0.250 in. (¼ in. drill) opening
Position No. 2	MR charges brake pipe through 0.0225 in. (No. 74 drill) opening
Position No. 3	Lap
Position No. 4	Brake pipe pressure reduces through 0.0465 in. (No. 56 drill) opening
Position No. 5	Brake pipe pressure reduces through 0.09375 in. (3⁄32 in. drill) opening
Position No. 6	Brake pipe pressure reduces through 0.1875 (3⁄16 in. drill) opening
⅜ in. Test Device Cock	Brake pipe pressure reduces through 0.375 in. (⅜ in. drill) opening





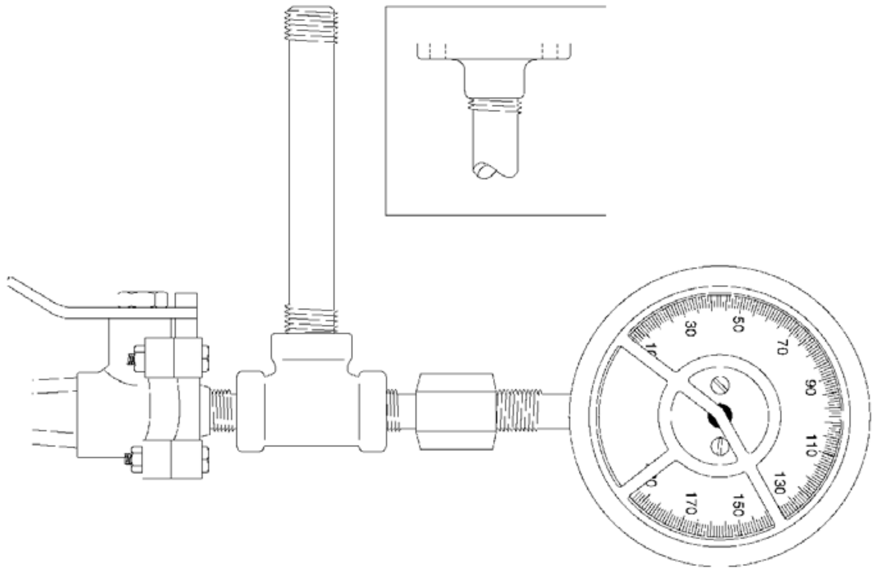
Model of Rotary Valve Seat

2.2 Test Gauge Arrangement

2.2.1 All gauges used during the following tests shall be an ASME Grade 2A gauge or equivalent as specified by ASME B40.1 or ASME B40.7. The recommended span of the gauge for measuring brake pipe pressure and main reservoir pressure is 200 psi. When measuring brake cylinder pressure or brake cylinder control pressure, the recommended span of the gauge is 100 psi.

2.2.2 The typical gauge arrangements consist of either a gauge or gauge with bleed cock, connected to a short length of hose and the appropriate equipment interface fitting (flange, test point, pipe tap, etc.). The equipment interface fittings shall provide an airtight seal and should be checked whenever leakage is detected during the test. Use the correct interface fitting for each test gauge connection as determined by the equipment manufacturer/operating authority. **Figure 4** shows a typical test gauge with bleed cock and pipe thread/flange fitting.

FIGURE 4
Test Gauge: Bleed Cock Arrangement



2.3 Dummy Couplings

2.3.1 One “F” type non-vented dummy coupling (brake pipe) and one “L” type non-vented dummy coupling (Main Reservoir) are required.

3. Calibration Requirements

3.1 Single Car Testing Device

To secure reliable and uniform results with the Single Car Testing Device, it shall be kept free from leakage and tested daily before use (see Section 15.1 for Daily Test). The Device shall not be used if it exceeds 92 days from first being placed in service. After 92 days of being in service, the Device shall be tested per Section 15.2. The Device may not be used in service if it exceeds 368 days from its last Section 15.2 test. Once every 368 days, the Device must be completely disassembled, cleaned and tested per manufacturer’s recommendations.

> **NOTE:** The Single Car Testing Device shall be verified as a Passenger Type Single Car Testing Device (SPFRS) and properly marked as such.

3.2 Ancillary Gauges

The gauges shall be calibrated after 92 days from first being placed in service and may not be used in service if they exceed 368 days from the date of last calibration. Electronic pressure gauges shall be calibrated at least once every 368 days.

3.3 Record Keeping

3.3.1 Single Car Testing Device and Ancillary Gauges shall be dated when last tested or calibrated per Section 15.2.

3.3.2 After being placed in service, the Single Car Testing Device and Ancillary Gauges must be tagged or labeled with the next due date for testing or calibration per Section 15.2.

4. General Test Procedures

4.1 Testing Device Preparation

4.1.1 The Single Car Testing Device shall be maintained in accordance with Section 15.

4.1.2 The Daily Test as specified in Section 15.1 shall be performed prior to using the Device on that day.

4.1.2.1 A source of clean, dry air shall be maintained at **120 psi** (100 psi) minimum to the Device during test for proper operation and results. An efficient air filter in the supply line ahead of the regulating valve shall be installed. Before the Device is attached to the supply line, the line shall be blown out.

4.1.2.2 Between the Device and the outlet hose coupling, which connects to the brake pipe hose on the car, the use of a hose is optional. If used, such outlet hose shall be of ¾ in. size with ½ in. connecting nipples and not greater than 8 ft. in length. A flat (roll-up) hose may be used to connect the Device to the car being tested; however, no kinks are allowed in the hose at any time during the test.

4.1.2.3 FLOWRATOR tube shall be within 15 deg. of vertical.

4.1.2.4 The Device ends, Device exhausts and test coupling shall be protected from contamination (entry of dirt).

4.1.2.5 The tests are to be made with the Device reducing valve adjusted for **110 psi** (90 psi).

4.1.3 Care should be exercised in moving the Device handle back to Position No. 3 (Lap) after making brake pipe reductions of 15 psi or more in Position No. 5 and Position No. 6. When the handle is snapped back, the temperature effect may cause the brake pipe pressure to rise 1½ to 2 psi and may be the cause of an undesired release. The Device handle should be moved slowly toward Lap position.

4.1.4 When making tests of cars having two sets of brake equipment, each set shall be tested separately, with the branch pipe Cut-Out Cock closed to one set while the other set is being tested.

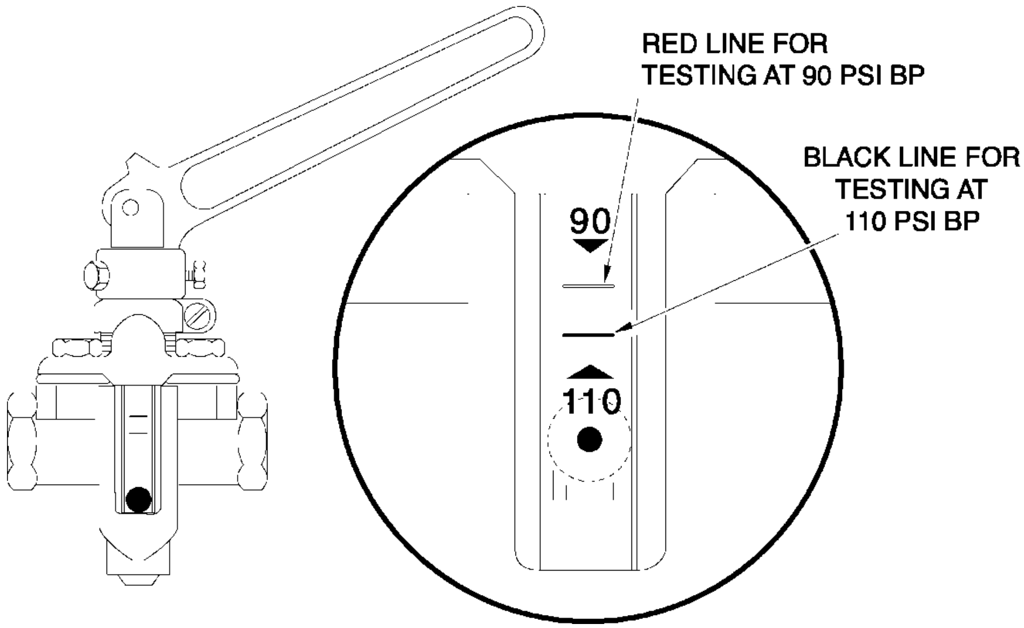
4.1.5 In the event of the valve failing to pass the specified test, it shall be ascertained that the Device and any test gauge attachments are not at fault.

4.1.6 To determine a "fully charged system" using the FLOWRATOR, move the Device handle into Position No. 1 and close the FLOWRATOR by-pass cock. If the ball remains below the condemning line (refer to 4.1.6.2) of the FLOWRATOR tube, then the system is fully charged. Open the FLOWRATOR by-pass cock. If the ball rises above the condemning line of the FLOWRATOR tube, then the system is not fully charged or the system has excess leakage. Open the FLOWRATOR by-pass cock and allow the system to continue charging, or assess potential leakage sources.

4.1.6.1 For equipment that uses equalization of the brake cylinder supply reservoir to the brake cylinders, a longer time period may be required to properly charge the control reservoir even if the FLOWRATOR ball is below the condemning line.

4.1.6.2 When using a FLOWRATOR calibrated for both 110 psi and 90 psi brake pipe, use the upper condemning (Red) line for 90 psi brake pipe and the lower (Black) line for 110 psi brake pipe, as shown in **Figure 5**.

FIGURE 5
FLOWRATOR Detail



4.1.7 If using a Device when the FLOWRATOR has been disqualified by the daily test in Section 15.1, the determination of a "fully charged system" shall be performed as follows:

4.1.7.1 Move the Device handle to Position No. 3 (Lap). If the brake pipe pressure decreases more than 1 psi in 1 minute, then the system is not fully charged or the system has excess leakage. Move the Device handle to Position No. 1 and continue charging or assess potential leakage sources.

4.2 General Information

4.2.1 As used in this standard, pounds per square inch (psi) shall indicate pressure as pounds per square inch gauge (psig) unless otherwise specified. The pressure measured is greater than ambient using ambient pressure as the reference.

4.2.2 As used in this standard, "brake cylinder" refers to all components connected to the brake cylinder line, including but not limited to the brake cylinder piping, tread brake units, disc brake units, brake cylinder indicators and wheel slide protection equipment.

4.2.3 As used in this standard, the term "Cut In" (OPEN) will be used to designate a cut-out cock that will allow the passage of air between equipment components. The term "Cut Out" (CLOSED) will be used to designate a cut-out cock that will prevent or stop the flow of air between equipment components.

4.2.4 Any ancillary equipment not identified or provided a test procedure with this standard shall be tested in accordance with equipment manufacturer/operating authority instructions, as described in Section 13.5.

4.2.5 Passenger cars equipped with freight-based brake systems shall be tested using equipment manufacturer/operating authority approved procedures in accordance with current Federal Regulations.

4.2.6 When a car is equipped with a main reservoir pipe, air pressure of **120 psi** (100 psi) minimum should be connected to the main reservoir trainline as instructed in the standard. The dual air source arrangement (brake pipe and main reservoir) will aid in reducing the test time and will not compromise test results.

4.2.7 Tests of car equipment shown herein may be performed in a different order than listed in this procedure, provided that the conditions for the test and the performance criteria described are adhered to.

4.2.8 The nominal values shown in **Table 1** need to be obtained from the operating authority for use in testing:

TABLE 1
Required Nominal Values[1]

	Air Spring Pressure	Brake Cylinder Pressure[2]	
		Service	Emergency
Non-Load-Weigh	0[3]	X[4]	X[4]
Empty (Light)			
Loaded (Heavy)[5]			

1. Nominal values represent the normal values that are obtainable on an “in-date” car. These values should be obtained from the equipment manufacturer/operating authority.
2. For equipment that uses equalization, the brake cylinder pressure tolerance shall be ±5 psi. This tolerance is based on volume variations in car piping.
3. Zero (0) Air Spring Pressure is used for cars not equipped with a load weigh system or the brake cylinder pressure when load weigh is Cut Out (Not Operating).
4. Only these pressures are required for cars not equipped with a load weigh system.
5. Loaded (Heavy) car air spring pressure shall be higher than the Empty (Light) car pressure such that the Loaded car brake cylinder pressure minus tolerance does not overlap the Empty car brake cylinder pressure plus tolerance. Heavy car air spring pressure does not have to be equivalent to maximum loaded pressure of the car.

5. Car Preparation

5.1 Safety

5.1.1 Chock wheels to prevent car movement during tests.

5.1.2 Follow car testing safety regulations of the operating authority.

5.2 Car Setup

5.2.1 Open cut-out cock(s) between the Main Reservoir and Air Spring system (if equipped).

5.2.2 Ensure that the hand brake/parking brakes are released where applicable.

5.2.3 If testing a cab car, the cab equipment details shall be conditioned so that the car brake equipment functions as a trailer car. Refer to equipment manufacturer/operating authority procedures for conditioning cab car equipment. Locomotive functions (service control of brake pipe) of cab cars shall be tested per current FRA regulations.

5.2.4 Water raising equipment should be Cut Out at the water filling valves or other appropriate locations as instructed by equipment manufacturer/operating authority.

5.2.5 Other ancillary equipment connected to the Main Reservoir shall be Cut Out. (See Section 13.5 for testing ancillary equipment.)

5.2.6 The brake system cocks shall be placed in the appropriate positions as listed in **Table 2** before testing begins.

TABLE 2
Brake System Cock Positions

Brake System Cocks	Position
Brake Pipe and Main Reservoir (If equipped) trainline cocks	OPEN
Brake Pipe Branch Pipe Cut-Out Cock	Cut In
All equipment cocks attached to Brake Pipe	Cut In
Brake Cylinder (Truck Cut-Out)	Cut In

SAFETY WARNING: Ensure that no air is on the car before making any of the following gauge connections. Plugs or blanking plates shall be carefully loosened before they are removed in order to minimize the possibility of personal injury from the effects of residual, pressurized air that may be in the equipment components.

5.2.7 Connect ASME Grade 2A gauge to the test points of the following: main reservoir trainline (if equipped), brake cylinder, control valve exhaust (10 port),* relay valve exhaust,* and load weigh (air spring) system (if equipped). A single gauge may be used but shall be moved between each test point during the testing procedures as required. The bleed cocks shall remain cut in (open) on the control valve and relay valve exhausts before beginning and throughout the procedures outlined in this standard unless otherwise instructed.

NOTE: For components marked with an asterisk (*), test gauge shall include a bleed cock to properly perform tests.

5.2.8 An ASME Grade 2A gauge may be connected to 16 pipe if desired by the operating authority to aid in testing.

6. Test Equipment Installation

6.1 Connecting the Device to Car

SAFETY WARNING: Care should be taken that all supply air is cut out to prevent any whipping or lashing of hoses and couplings. Make certain that all test gauges and the Device are fastened and/or connected securely to minimize the possibility of personal injury from parts that may be "blown" from the test arrangement when air is admitted to the Device or brake equipment.

6.1.1 Close the branch pipe cut-out cock on the car and ensure that all reservoirs are completely drained. All reservoir drain cocks should be closed.

6.1.2 Connect the Device end marked B.P. to the brake pipe hose at one end of the car (preferably the B end of the car).

6.1.3 Connect the supply line to the end of the Device near the reducing valve.

6.1.4 Make sure that the FLOWRATOR by-pass cock is open and that both angle cocks are open. Open the supply air cut-out cock.

6.1.5 TEST: Move the Device handle to Position No. 1. A continuous flow of air must occur from the open brake pipe hose at the opposite end of the car.

6.1.6 Close the brake pipe angle cock at the end opposite of the Device, and couple on a non-vented "F" type dummy hose coupling. Reopen the brake pipe angle cock slowly while holding the end hose to control movement.

> **NOTE:** For cars not equipped with a main reservoir trainline, proceed to Section 7.

6.1.7 Close all drains and cutout cocks of main reservoir trainline.

> **NOTE:** Make sure main reservoir trainline gauge is not isolated.

6.1.8 TEST: With a gauge connected to the main reservoir (MR) trainline, monitor the MR trainline pressure. MR trainline pressure shall not increase in 3 minutes.

6.1.9 Open MR trainline end cut-out cocks as necessary.

6.1.10 Continue charging the brake pipe and reservoirs to **110 psi** (90 psi).

7. Leakage Tests

7.1 System Leakage Test

7.1.1 TEST: Close the FLOWRATOR by-pass cock. If the ball is not above the condemning line, then open the FLOWRATOR by-pass cock and proceed directly to Section 7.2, "Main Reservoir Leakage" (if equipped). If any part of the ball is above the condemning line, then make a complete check for leakage (with soap suds when weather conditions permit) of all pipes and pipe connections, including angle cocks, hoses, check valves and auxiliary components.

7.1.2 If leakage is found, then make repairs necessary to reduce it to where the ball of the FLOWRATOR stays below the condemning line. Then open the FLOWRATOR by-pass cock and proceed to Section 7.2, "Main Reservoir Leakage" (if equipped).

7.2 Main Reservoir Leakage

> **NOTE:** For cars not equipped with a main reservoir trainline, proceed to Section 8.

> **NOTE:** The air supplied to the main reservoir pipe shall be taken from the supply side of the Device or an alternate air supply line. Before making any hose connection, the supply line shall be blown out.

7.2.1 With a gauge connected to the main reservoir trainline and the test air supply cut-out cock closed, make a connection of a **120 psi** (or **100 psi** if testing a car with a main reservoir pass-through pipe) minimum supply air (air shall be from a clean, dry source) to the main reservoir pipe hose at one end of the car.

7.2.2 TEST: With both main reservoir trainline cocks open, partially open the test air supply cut-out cock and note the continuous flow of air from the main reservoir hose opening at the opposite end of the car.

7.2.3 Close the main reservoir trainline cock at the end of the car opposite the test supply air connection.

7.2.4 Connect a non-vented “L” type dummy hose coupling to the main reservoir pipe hose coupling and open the main reservoir trainline cock.

7.2.5 Open the main reservoir test air supply cock and charge the main reservoir system.

7.2.6 Main Reservoir Leakage (non pass-through)

> **NOTE:** For cars equipped with a main reservoir pass-through pipe, proceed to Section 7.2.7.

7.2.6.1 Move the Device handle to Position No. 5, and make a 10 psi reduction in brake pipe. Move the Device handle into Position No. 3 (Lap).

7.2.6.2 TEST: After 30 seconds, observe the Device gauge. Pressure increase shall not exceed 3 psi in 1 minute and shall stabilize.

7.2.6.3 Close the main reservoir test air supply cock.

7.2.6.4 TEST: Observe the main reservoir gauge. Pressure decrease shall not exceed 5 psi in 1 minute.

7.2.6.5 Open the main reservoir test air supply cock, move the Device handle to Position No. 1 and fully charge the brake equipment.

7.2.6.6 Proceed to Section 8.

7.2.7 Main Reservoir Leakage (pass-through)

> **NOTE:** “Pass-Through” means no pneumatic equipment connected to the pipe.

7.2.7.1 Pressurize the Main Reservoir pipe to 100 psi minimum and close air supply cut-out cock.

7.2.7.2 TEST: After 30 seconds, observe the main reservoir gauge. Pressure decrease shall not exceed 5 psi in 1 minute and shall stabilize.

8. Functionality Testing

8.1 Preparation

8.1.1 Cars equipped with a pneumatic cutoff valve controlling the load weigh system shall either temporarily disable the variable load valve or inhibit its operation. The air spring pressure shall be reduced a minimum of 10 psi below the Light (Empty Car) air spring pressure.

> **NOTE:** Some variable load valve arrangements may require that the air spring pressure be reduced to zero (0) psi for proper determination of the non-load-weigh brake cylinder pressure. Check with the equipment manufacturer/operating authority for details on preparation of equipment for this test.

8.2 Service Stability Test

8.2.1 Confirm installation of an air gauge in the brake cylinder line. With the equipment fully charged, move the Device handle to Position No. 5, reducing brake pipe pressure 27 psi, and then slowly move handle to Position No. 3 (Lap).

8.2.2 TEST: This test shall not produce an emergency application.

8.2.3 TEST: Allow 20 seconds for the brake cylinder gauge to stabilize. Observe the brake cylinder gauge, and verify that the non-load weigh service brake cylinder pressure ± 3 psi as specified is correct. Then note that brake cylinder pressure increases no more than 3 psi in 1 minute.

8.3 Release Testing

Cars shall be tested for Direct and/or Graduated release based on the type of service in which the car is intended to be used. Intended service is that service in which the car is operated in an ongoing basis between prescribed single car testing intervals. If a car's brake release configuration is required to change from direct to graduated or graduated to direct to meet the train operating requirements, then the brake equipment must be tested in graduated and direct release configurations.

> **CAUTION:** When changing the Graduated/Direct Release Cap or other related covers, refer to the equipment manufacturer/operating authority instructions.

For cars equipped with an EAB system release, testing shall be tested in both normal and back-up mode in accordance with equipment manufacturers/operating authority procedures.

8.3.1 Direct Release Test

> **NOTE:** For cars operated in Direct release service, ensure that the Graduated/Direct release cap is in the Direct release position. Cars operated only in Graduated release service shall have the Graduated/Direct release cap left in the Graduated release position.

For cars operated only in graduated release service, proceed to Section 8.3.2.

8.3.1.1 TEST: With a 27 psi brake pipe reduction in effect, move the Device handle to Position No. 1 until brake pipe pressure has increased 10 to 11 psi; then move handle to Position No. 3 (Lap) and note that brake cylinder control (port 10 exhaust) pressure shall fully exhaust.

8.3.1.2 Move the Device handle to Position No. 1 to fully recharge the brake pipe and reservoirs. Check that the equipment is fully charged and the brakes are released.

8.3.2 Graduated Release Test

For cars operated only in direct release service, proceed to Section 8.4.

> **NOTE:** Cars operated only in Graduated release service or cars operated in both Graduated and Direct release service shall be tested in the manner described by this section. Ensure that the Graduated/Direct release cap is placed in the Graduated position before proceeding with this section.

> **NOTE:** Cars equipped with variable load control systems shall be tested in the Loaded (Heavy) Car condition.

> **CAUTION:** When changing the Graduated/Direct Release Cap or other related covers, refer to the equipment manufacturer/operating authority instructions.

8.3.2.1 Move the Device handle to Position No. 1 to fully recharge the brake pipe and reservoirs.

8.3.2.2 Make a 27 psi brake pipe reduction, and then move the Device handle to Position No. 3 (Lap).

8.3.2.3 TEST: Move the Device handle to Position No. 1 until brake pipe pressure has increased 8 to 9 psi; then move the Device handle to Position No. 3 (Lap). Brake cylinder control (port 10 exhaust) pressure shall partially exhaust and stabilize.

8.3.2.4 TEST: Move the Device handle to Position No. 1 until brake pipe pressure has increased 3 to 4 psi; then move the Device handle to Position No. 3 (Lap). Brake cylinder control (port 10 exhaust) pressure shall partially exhaust and stabilize.

8.3.2.5 TEST: Repeat Section 8.3.2.4.

8.3.2.6 Move the Device handle to Position No. 1 to fully recharge the brake pipe and reservoirs.

8.4 Application and Release Sensitivity Test

> **NOTE:** For PS-68 Type brake equipment, a 10 psi reduction is required.

8.4.1 With the equipment fully charged, move the Device handle to Position No. 5 until a 5 psi brake pipe reduction is obtained; then slowly move the handle to Position No. 3 (Lap). The brake pipe pressure shall continue to drop to within a **104 psi** (84 psi) maximum and a **100 psi** (80 psi) minimum allowable pressure range. If brake pipe pressure stabilizes between **100 psi** (80 psi) and **104 psi** (84 psi), then proceed to Section 8.4.2.

8.4.1.1 If brake pipe reduction continues after the Device handle is placed in Position No. 3, then move the Device handle to Position No. 2 until the brake pipe pressure stops reducing. Then immediately move the Device handle back to Position No. 3 (Lap).

> **NOTE:** Brake Pipe pressure reduction must not reduce past **94 psi** (74 psi) while in Position No. 2. If Brake Pipe reduces past **94 psi** (74 psi) then repeat Section 8.4.1.

8.4.2 TEST: Allow 20 seconds for the brake cylinder gauge to stabilize. The brake cylinder pressure shall not increase/decrease more than 3 psi in 1 minute. With this application, the brake shoes/pads shall be in firm contact with the braking surfaces.

> **NOTE:** During the Release Sensitivity Test, the reducing valve supply pressure shall not decrease more than 2 psi.

8.4.3 Move the Device handle to Position No. 2.

8.4.4 TEST: Brake cylinder pressure shall begin to decrease within 90 seconds as indicated by an exhaust of air from the 16 pipe exhaust (port 10 or equivalent) or by a reduction of brake cylinder measured at the brake cylinder gauge.

8.4.5 Continue the test until brake cylinder pressure is zero (0) psi and brake shoes/pads are fully released from the braking surfaces as defined by the equipment manufacturer/operating authority.

8.4.6 Move the Device handle to Position No. 1 and fully recharge the brake system.

9. Emergency Brake Application Tests

9.1 Emergency Test (Auxiliary Venting Portions)

> **NOTE:** The following test shall be individually performed for each auxiliary venting portion on the car. Portions not being tested shall be Cut Out/Plugged.

9.1.1 Plug all auxiliary brake pipe emergency venting portions except the one being tested.

9.1.2 Verify that the system is fully charged. Move the Device handle to Position No. 5 and make a 27 psi reduction in brake pipe pressure. Move the Device handle to Position No. 3 (Lap).

9.1.3 Cut Out/Plug the control valve/operating unit emergency venting portion.

9.1.4 TEST: With the Device handle in Position No. 3 (Lap), open the Device ⅜ in. cock. This test shall produce an emergency reduction as indicated by the opening of the auxiliary venting portion and the sudden decrease in brake pipe pressure.

9.1.5 Close the Device ⅜ in. cock.

9.1.6 If this is the last auxiliary venting portion to be tested, install a plug in the tested portion; then proceed to Section 9.1.8. Otherwise install a plug in the tested valve and remove the plug from the next device to be tested.

9.1.7 Move the Device handle to Position No. 1 and recharge equipment. Proceed to Section 9.1.2 to test the remaining auxiliary venting portions.

9.1.8 Cut In/unplug the control valve/operating unit emergency venting portion.

9.1.9 Move the Device handle to Position No. 1 to fully recharge brake pipe and reservoirs.

9.2 Emergency Test (Control Valve/Operating Unit)

> **NOTE:** This section applies only if the control valve/operating unit includes a feature for brake pipe emergency venting.

9.2.1 Verify that all auxiliary venting portion(s) are plugged.

9.2.2 With the equipment fully charged, move the Device handle to Position No. 5 and make a 27 psi reduction in brake pipe pressure. Move the Device handle to Position No. 3 (Lap).

9.2.3 TEST: Open the Device ⅜ in. cock. This test shall produce an emergency application as indicated by opening of the control valve/operating unit emergency venting portion and the sudden decrease in brake pipe pressure.

9.2.4 TEST: Allow 20 seconds for the brake cylinder gauge to stabilize. Observe brake cylinder gauge, and verify that the non-load weigh emergency brake cylinder pressure ±3 psi (or equalization pressure) as specified is correct.

9.2.5 Remove plugs from all emergency venting portions, and install all vent protectors.

9.3 Brake Cylinder Cut-Out Cocks

> **NOTE:** If car is equipped with remote handles on the brake cylinder cut-out cocks, then ensure proper operation of the remote handles during this test.

9.3.1 TEST: With the brakes applied at emergency brake cylinder pressures, close one brake cylinder cut-out cock and verify that the associated brakes release as indicated by the release of the brake shoes/pads from the braking surfaces as defined by the equipment manufacturer/operating authority. Also verify the proper operation of any brake cylinder pressure indicators (including illuminated indicators).

9.3.2 Open brake cylinder cut-out cock.

9.3.3 Repeat item 9.3.1 for each brake cylinder cut-out cock on the car.

9.4 Release Test after Emergency

9.4.1 TEST: At the completion of the Emergency Tests, close the Device ⅜ in. cock. Verify that brake pipe pressure on the Device gauge does not increase for 2 minutes.

9.4.2 Move the Device handle to Position No. 1 and recharge the equipment.

10. Leakage Tests—Control Valve and Brake Cylinder

10.1 Control Valve

For cars equipped with EAB systems, control valve leakage or equivalent shall be tested per equipment manufacturer/operating authority procedures.

10.1.1 Verify connection of the gauge to the control valve exhaust (26-C 10 port) and close the bleed cock.

10.1.2 With the equipment fully charged, reduce brake pipe pressure 27 psi in Position No. 5 and then move the Device handle to Position No. 1. If test gauge indicates a pressure in excess of 50 psi, then the pressure shall be reduced to 50 psi through the bleed cock.

> **NOTE:** If the control valve exhaust (10 port) gauge pressure does not exceed 50 psi, then test leakage at the pressure obtained.

10.1.3 TEST: Observe the test gauge for leakage from the combined volumes of the relay valve diaphragm chamber, 16 pipe/10 port (if used) and their related piping, which shall not exceed 2 psi in 1 minute.

10.1.4 Open the bleed cock on 10 port.

10.2 Brake Cylinder Leakage

> **NOTE:** If the car is not equipped with a brake cylinder relay valve, proceed to Emergency Brake (Conductor's Valve Test) Section 11.

EAB systems utilizing electronic brake cylinder control shall provide a means of isolating the electronic brake cylinder control from maintaining brake cylinder pressure.

10.2.1 Verify connection of the gauge to the relay valve exhaust or brake cylinder line.

10.2.2 With the equipment fully charged, reduce brake pipe pressure 27 psi in Position No. 5, and then slowly move the Device handle to Position No. 3 (Lap).

10.2.3 Close the bleed cock on the test gauge or isolate the brake cylinder pressure maintaining from the brake cylinder control valve.

10.2.4 Move the Device handle to Position No. 1. The pressure obtained by the reduction shall be the non-load-weigh full-service brake cylinder pressure but not to exceed 50 psi. If the brake cylinder pressure on the test gauge is in excess of 50 psi, then the pressure shall be reduced to 50 psi through the bleed cock.

> **NOTE:** If the brake cylinder gauge pressure does not exceed 50 psi, then test leakage at the pressure obtained.

10.2.5 TEST: Observe the test gauge for leakage from the combined volumes of the brake cylinders and their related piping. The drop in pressure shall not exceed 3 psi in 1 minute.

10.2.6 Open the bleed cock on the test gauge.

11. Emergency Brake (Conductor’s) Valve Test

> **NOTE:** The following test shall be performed for the first Emergency Brake Valve tested on the car. The remaining Emergency Brake Valves shall be tested in accordance with Section 11.2. For Emergency Brake Valves equipped with multiple operating mechanisms, each operating mechanism must be verified.

11.1 TEST: With the equipment fully charged and the Device handle in Position No. 1, open the emergency brake (conductor’s) valve, observing carefully to ensure that there are no obstructions to the free and full movement of the operating mechanism and that there is no binding of parts. The opening of the emergency brake (conductor’s) valve shall produce an emergency reduction.

11.2 Repeat item 11.1.1 for each remaining emergency brake (conductor’s) valve. Allow sufficient time after testing of each valve so that the system may reset and begin to charge. A full charge of the brake system is not required to test the function of the remaining Emergency Brake (Conductor’s) Valves and application valves.

12. Variable Load Control

For cars not equipped with a variable load control system, proceed to Section 13.

> **NOTE:** This section provides a guide to testing the variable load control system. The test may be performed as described below, or the test may be modified or performed in any sequence to meet the specific operation of a particular variable load control system. The modified procedure shall agree with the original equipment manufacturer’s requirements.

Cars equipped with EAB systems with electronic load correction shall be tested per Section 12 if applicable or in accordance with equipment manufacturer/operating authority’s instructions.

12.1 Empty (Light) Car

12.1.1 Increase the Air Spring pressure to within ±1 psi of the Empty (Light) Car pressure, as specified in Section 4.2.8.

12.1.2 With the equipment fully charged, move the Device handle to Position No. 5 until a 27 psi brake pipe reduction is obtained; then slowly move the Device handle to Position No. 3 (Lap). When testing cars equipped with an accelerated, continuous service application feature (B-1 Quick Service Valve or Accelerated Application Valve), a greater quick service activity will be indicated by the continual decrease in brake pipe pressure. If brake pipe pressure has not stopped dropping before it reaches 55 psi, as indicated by the Device gauge, then move the Device handle to Position No. 2 until the brake pipe pressure stops reducing. Then immediately move the Device handle back to Position No. 3 (Lap).

12.1.3 TEST: Allow 20 seconds for the system to stabilize. Ensure that the brake cylinder gauge pressure is within ±3 psi of the Empty (Light) Car full-service brake cylinder pressure, as specified is correct.

12.1.4 Move the Device handle to Position No. 1 and fully recharge the system.

12.1.5 Move the Device handle to Position No. 3 (Lap).

12.1.6 Open the Device ⅜ in. cock. The test shall produce an emergency brake application.

12.1.7 TEST: Allow 20 seconds for the system to stabilize. Ensure that the brake cylinder gauge pressure is within ±3 psi of the Empty (Light) Car emergency brake cylinder pressure, as specified is correct.

12.1.8 Close the Device ⅜ in. cock and move the Device handle to Position No. 1.

12.2 Loaded (Heavy) Car

12.2.1 Increase the Air Spring pressure to within ±1 psi of the Loaded (Heavy) Car pressure, as specified in Section 4.2.8.

12.2.2 With the equipment fully charged, move the Device handle to Position No. 5 until a 30 psi brake pipe reduction is obtained, and then slowly move the Device handle to Position No. 3 (Lap). When testing cars equipped with an accelerated, continuous service application feature (B-1 Quick Service Valve or Accelerated Application Valve), a greater quick service activity will be indicated by the continual decrease in brake pipe pressure. If brake pipe pressure has not stopped dropping before it reaches 55 psi, as indicated by the Device gauge, then move the Device handle to Position No. 2 until the brake pipe pressure stops reducing. Then immediately move the Device handle back to Position No. 3 (Lap).

12.2.3 TEST: Allow 20 seconds for the system to stabilize. Ensure that the brake cylinder gauge pressure is within ±3 psi of the Loaded (Heavy) car full-service brake cylinder pressure, as specified is correct.

12.2.4 Move the Device handle to Position No. 1 and fully recharge the system.

12.2.5 Move the Device handle to Position No. 3 (Lap).

12.2.6 Open the Device ⅜ in. cock. The test shall produce an emergency brake application.

12.2.7 TEST: Allow 20 seconds for the system to stabilize. Ensure that the brake cylinder gauge pressure is within ±3 psi of the Loaded (Heavy) car emergency brake cylinder pressure, as specified is correct.

12.2.8 Close the Device ⅜ in. cock.

13. Miscellaneous Devices

If the car is equipped with any of the equipment listed below, it shall also be tested as part of the Single Car Test. At completion of previous testing, brake equipment will have brakes applied. Manufacturer/operating authority instructions shall be followed to condition equipment for the following tests.

13.1 Hand Brake/Parking Brake

13.1.1 TEST: Hand brake/parking brake unit shall be tested in accordance with manufacturer/operating authority instructions.

13.2 Wheel Slide Protection Equipment

13.2.1 TEST: Wheel Slide equipment shall be tested in accordance with manufacturer/operating authority instructions.

13.3 Conductor's Signal System

13.3.1 TEST: Conductors signal systems shall be tested in accordance with manufacturer's instructions. If car is equipped with air signal equipment, it shall be tested in accordance with Instruction Leaflet No. 2377-2, July 1942.

13.4 Electropneumatic Operation

13.4.1 TEST: Cars with Electropneumatic operation capabilities shall be tested in accordance with manufacturer/operating authority instructions.

13.5 Ancillary Pneumatic Equipment

13.5.1 TEST: Any ancillary pneumatic equipment not described by this standard shall be tested in accordance with manufacturer/operating authority instructions. Brake system shall not be adversely affected by ancillary pneumatic equipment operation.

13.5.2 TEST: If ancillary pneumatic equipment is cut out during leakage tests as described in Section 7, then appropriate leakage tests shall be performed on ancillary pneumatic equipment. The summation of all leakages shall not exceed the limits specified in Section 7.

14. Completion of Testing

14.1 Test Equipment

14.1.1 Safely remove all gauges from their respective test points where applicable.

14.1.2 If the gauges were connected by the removal of pipe plugs, leakage shall be tested. No pipe plug leakage is allowed.

14.1.3 Safely disconnect the Device from the car. Connect a dummy coupling to all hose connections and the Device to prevent contamination from dust or dirt.

14.2 Final Car Preparation

14.2.1 Ensure that hand brake/parking brake is applied.

14.2.2 Ensure that all car equipment is restored to operating configuration, as specified by operating authority.

14.2.3 Record car and test information as specified by the operating authority and federal regulation.

15. Single Car Test Device—Testing

15.1 Daily Test for Single Car Testing Device

15.1.1 This test is to be performed at least once each day of use. Connect the Device to a source of clean, dry air, which shall be maintained at **120 psi** (100 psi) minimum to the Device during test for proper operation and results. An efficient air filter in the supply line ahead of the regulating (feed) valve shall be installed. Before the Device is connected to the supply line, the supply line shall be blown out. Open the FLOWRATOR by-pass cock and close the ⅜ in. test cock.

15.1.2 Move the Device handle to Position No. 2 and note a continuous flow of air at the Device brake pipe hose coupling.

15.1.3 Move the Device handle to Position No. 3 (Lap). Test for leakage at brake pipe connection and rotary valve exhaust. This leakage, when detected with soap suds, shall not exceed a 1 in. bubble in 5 seconds.

15.1.4 Move the Device handle to Position No. 2. Close and open FLOWRATOR by-pass cock. Observe that the ball does not stay at the top of the tube.

15.1.5 Move the Device handle to Position No. 3 (Lap). Couple the test coupling with orifice to the brake pipe coupling end (BP) of the Device. Move the Device handle to Position No 1. Close the FLOWRATOR by-pass cock. Note that the FLOWRATOR ball rises and floats in the tube in the zone between the Red condemning line and the top of the tube (Test applies for both 90 psi and 110 psi operation). The test coupling may be connected to the end of a hose connected to the Device as described in Section 4.1.2.2. However, a greater time shall be given before condemning the FLOWRATOR due to the increased volume of the hose.

a) If the Device fails, check coupling and gaskets for leakage (none allowed). Inspect the exhaust end of test coupling to ensure that it is clean and free of obstructions. If this does not correct the failure, then the FLOWRATOR shall not be used to qualify leakage or fully charged system until the Device and test coupling are returned for maintenance to requalify the test coupling and FLOWRATOR.
b) If the Device FLOWRATOR has failed the above test, it may be used by following the procedures for determination of leakage/fully charged system outlined in Section 4.1.7.

15.1.6 Move the Device handle to Position No. 3 (Lap). Open the FLOWRATOR by-pass cock and the Device ⅜ in. cock.

15.1.7 Remove and properly store the test coupling. Close the Device ⅜ in. cock.

15.2 92-day Test for the Single Car Testing Device and Test Coupling

The Device shall be tested at either 110 psi or 90 psi based on the operating pressure of the brake equipment being tested and pass the procedure using either the standard test rack or the alternate test rack according to **Table 3**. If the Device is used for 110 psi and 90 psi type equipment then the 110 psi sections shall be used.

TABLE 3
Test Procedures

Test Rack	Test Device	Test Coupling
Standard Test Rack	15.2.1	15.2.3
Alternate Test Rack	15.2.2	15.2.4

The Single Car Testing Device shall be maintained according to the requirements of Section 3.

The test coupling is part of the Device and shall be returned for requalification with the Device. Testing of the test coupling is to be performed according to Section 15.2.3 when using the standard test rack and Section 15.2.4 when using the alternate standard test rack.

As often as service conditions require, the rotary valve shall be lubricated with a suitable grease or lubricating oil (AAR Spec M-912). Lubricate the standard quick opening diaphragm cock cam with a small amount of grease (AAR Spec M-914).

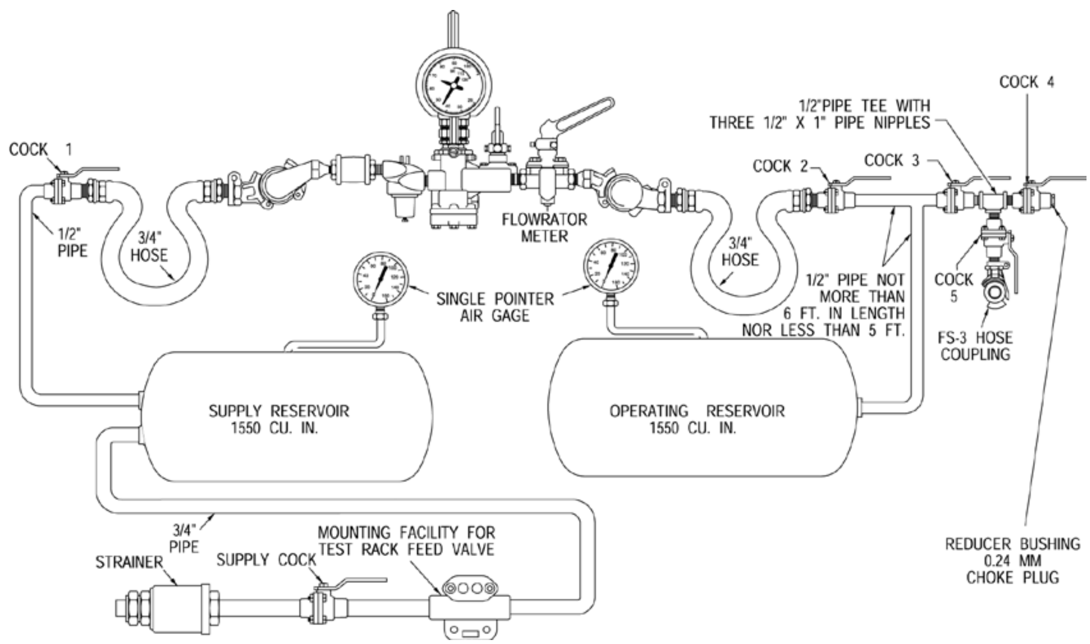
The Device test gauge shall be compared with a master gauge for accuracy as often as the Device itself is being tested. The master gauge is to be calibrated according to ASME standards. The calibration of the master gauge shall be performed annually or as required by ASME standards.

The strainer filter shall be replaced annually unless service conditions warrant a more frequent replacement.

15.2.1 Test Procedure for Single Car Testing Device with FLOWRATOR on Standard Test Rack

FIGURE 6

Standard Rack for Testing Passenger Single Car Testing Device



Qty.	Description	Wabtec PC	Knorr PC
1	Air strainer	70800	700270*
1	¾ in. supply cock OR	572465 572460	784407-0121, 704498*
	OR diaphragm cock	519873	—
1	Type DB-24-B feed valve pipe bracket	542011	733115*
5	½ in. cutout cocks (Nos. 1, 2, 3, 4, 5)	572464 572459	784405-0121, 704495*
	OR diaphragm cock	96878	—

1	Supply reservoir	530851	704672*
1	Operating reservoir	530869	702996*
2	Single pointer air gauge	88882	710216, 700437*
1	Choke fitting with choke(s)	655009	809906*
2	¾ in. × 56 in. hose with 2½ in. threaded nipples	549772	—
2	¾ in. × 2½ in. face bushing	537659	—
3	FS-3 hose coupling	87817	782884, 700510*

* Part number is obsolete but may be used if available.

15.2.1.1 Attach the Device to the rack as illustrated by **Figure 6**. Open the supply cock, cock 1, cock 2 and FLOWRATOR by-pass cock. Move the Device handle into Position No. 1. Adjust the test rack regulating valve to close between **120–125 psi** (100 psi) as indicated on the test rack supply reservoir gauge.

> **NOTE:** If the pressure indicated on the test rack supply reservoir gauge should rise above **125 psi** (100 psi), then the Device ⅜ in. cock should be opened to release air trapped in the system. While the Device ⅜ in. cock is open, the reducing or feed valve should be turned down below the set pressure. Once the test rack feed valve or the Device reducing valve set point has been turned back down, close the Device ⅜ in. cock, and readjust the feed or reducing valve. The pressure setting of either the Device reducing valve or the test rack feed valve shall be set by increasing to the set pressure and never by decreasing to the set pressure.

15.2.1.2 Verify the Device reducing valve is set to close at **110 psi** (90 psi) as indicated by the operating reservoir gauge. If the Device reducing valve does not close at **110 psi** (90 psi), then adjust the valve to properly close at **110 psi** (90 psi).

> **NOTE:** If the pressure indicated on the test rack operating reservoir gauge should rise above **110 psi** (90 psi), then the Device ⅜ in. cock should be opened to release air trapped in the system. While the Device ⅜ in. cock is open, the reducing valve should be turned down below the set pressure. Once the reducing valve set point has been turned back down, close the Device ⅜ in. cock, and readjust the reducing valve. The pressure setting of the Device reducing valve shall be set by increasing to the set pressure and never by decreasing to the set pressure.

15.2.1.3 Operate the Device several times by moving the Device handle from Position No. 1 to Position No. 6, finally leaving the handle in Position No. 3 (Lap).

15.2.1.4 Close Cock 1, and open the Device ⅜ in. cock until the operating reservoir gauge indicates zero (0) psi. Close the Device ⅜ in. cock.

15.2.1.5 Commence test with all numbered cocks closed and the Device handle in Position No. 3 (Lap). Open Cock 1 and the Device ⅜ in. cock. Coat the opening of the ⅜ in. cock with soap suds in order to detect rotary valve leakage to brake pipe. Leakage must not exceed a 1 in. bubble in 5 seconds.

15.2.1.6 Close the ⅜ in. cock and move the Device handle to Position No. 6, and then coat the Device exhaust port with soap suds in Positions No. 6, 5, 4, 3, 2 and 1 consecutively. Leakage must not exceed a 1 in. bubble in 5 seconds.

15.2.1.7 Open cock 2, and when operating reservoir pressure reaches 38 psi, move the Device handle to Position No. 2. Note that the operating reservoir charges from 40 to 45 psi in **21 to 26 seconds** (28 to 33 seconds).

15.2.1.8 Close FLOWRATOR by-pass cock and move the Device handle to Position No. 1. Note that operating reservoir charges from 50 to 80 psi in **10 to 16 seconds** (20 to 25 seconds).

15.2.1.9 Open the FLOWRATOR by-pass cock. After the operating reservoir is charged to **110 psi** (90 psi), compare OPERATING RESERVOIR and DEVICE gauges and ensure that the gauge hands register within ½ psi.

15.2.1.10 FLOWRATOR Ball Test

a) Close the FLOWRATOR by-pass cock. There should be no indication of airflow. Open the FLOWRATOR by-pass cock and open Cocks 3 and 4, allowing air to vent through the choke fitting (or chokes) of the test rack.
b) Close the FLOWRATOR by-pass cock. The ball should rise and float in the tube in the zone between the condemning line and the top of the tube.

NOTE: If the FLOWRATOR fails to pass this test, the ball and glass tube of the FLOWRATOR should be cleaned using a non-residue-producing solution to remove any oil or foreign matter, which may be carried into the Device. When the tube is properly installed in the FLOWRATOR cock, the dot on the tube should be below the condemning line.

15.2.1.11 Close Cock 3 and wait until flow of air from choke fitting stops; then open the FLOWRATOR by-pass cock and close Cock 4.

Wait a minimum of 45 seconds before commencing each of the following tests:

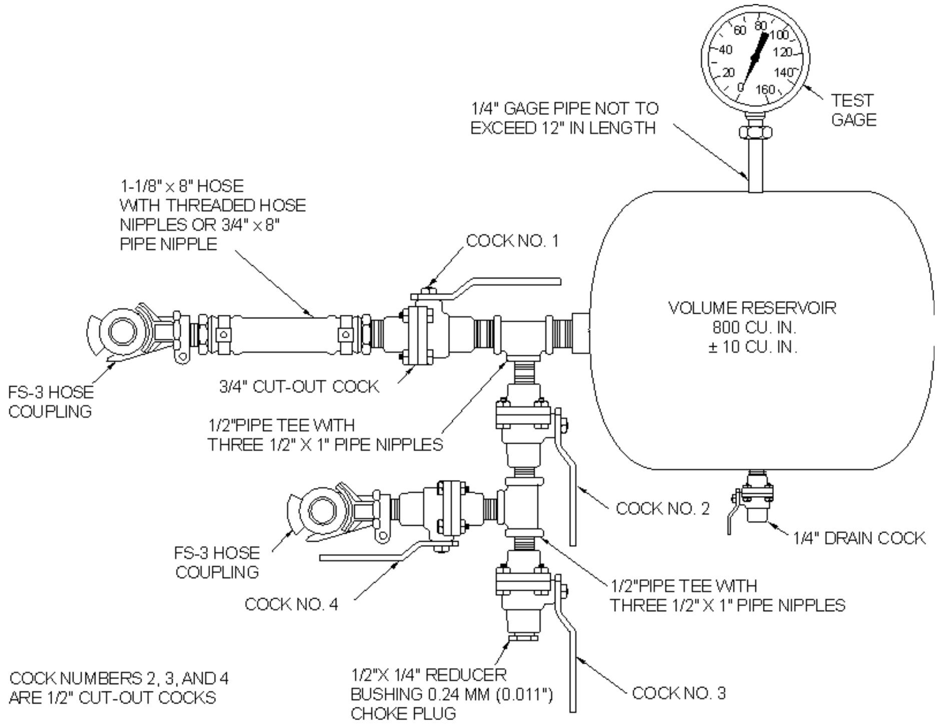
a) Move the Device handle to Position No. 4. The operating reservoir pressure shall reduce from **100 to 90 psi** (80 to 70 psi) in **8.5 to 11.5 seconds** (11.5 to 14.5 seconds). At the completion of the test, move the Device handle to Position No. 1 and recharge to **110 psi** (90 psi).
b) Move the Device handle to Position No. 5. The operating reservoir pressure shall reduce from **100 to 60 psi** (80 to 40 psi) in **10 to 13 seconds** (14.5 to 17.5 seconds). At the completion of the test, move the Device handle to Position No. 1 and recharge to **110 psi** (90 psi).
c) Move the Device handle to Position No. 6. The operating reservoir pressure shall reduce from **100 to 40 psi** (80 to 30 psi) in **5 to 9 seconds** (6 to 9.5 seconds). At the completion of the test, move the Device handle to Position No. 1 and recharge to **110 psi** (90 psi).
d) Move the Device handle to Position No. 3 (Lap). Open the Device ⅜ in. cock and observe on the operating reservoir gauge that the operating reservoir pressure reduces from **110 to 20 psi** (90 to 20 psi) in **3.75 to 4.25 seconds** (3 to 3.5 seconds).
e) At the completion of the test, close Cock 1, open the Device ⅜ in. cock and allow the Device Gauge to decrease to zero (0) psi. Close the Device ⅜ in. cock, and close the remaining test rack cocks. Remove the Device from the test rack.

15.2.2 Test Procedure for Standard Single Car Testing Device with FLOWRATOR on

Alternate Test Rack

FIGURE 7

Alternate Rack for Testing the Passenger Single Car Testing Device



Qty.	Description	Wabtec PC	Knorr PC
1	FS-3 hose coupling	87737	782884, 700510*
1	1⅛ in. × 8 in. hose with threaded nipples	516188	779071-0110
	Or ¾ in. × 8 in. pipe nipple	—	—
1	¾ in. supply cock	572465 572460	784407-0121, 704498*
	OR diaphragm cock	519873	—
3	½ in. cutout cocks (Nos. 2, 3, 4)	572464, 572459	784405-0121, 704495*
	OR diaphragm cock	96878	—
1	Volume reservoir	530848	704324
1	¼ in. gauge pipe not to exceed 2 in. length	—	—
1	Single pointer air gauge	88882	710216, 700437*
1	Choke fitting with choke(s)	655009	809906*
1	¼ in. drain cock	580867, 41814*	760691

* Part number is obsolete but may be used if available

For air supply adjustment, see Sections 15.2.2.1–15.2.2.4. Skip to Section 15.2.2.5 if the supply line is already regulated.

15.2.2.1 With all of the cocks closed, attach supply line to test rack volume reservoir coupling (**Figure 7**). The air supply shall meet the requirements as specified in Section 4.1.2.1.

15.2.2.2 Open the supply cock, FLOWRATOR by-pass cock and Cock 1. Adjust the supply regulating valve to close between **120 and 125 psi** (at 100 psi), as indicated by the test gauge. *(It is recommended that this regulating valve setting be at 120 psi.)*

> **NOTE:** If the pressure indicated on the test rack volume reservoir gauge should rise above **125 psi** (100 psi), then the volume reservoir drain cock should be opened to release air trapped in the system. While the drain cock is open, the reducing valve should be turned down below the set pressure. Once the reducing valve set point has been turned back down, close the drain cock and readjust the reducing valve. The pressure setting of the reducing valve shall be set by increasing to the set pressure and never by decreasing to the set pressure.

15.2.2.3 Close the supply cock and slowly open the reservoir drain cock and reduce test rack volume reservoir pressure to zero (0) psi.

15.2.2.4 Disconnect the supply line from the volume reservoir coupling and close the reservoir drain cock.

15.2.2.5 Attach the FLOWRATOR end of the Device to the volume reservoir coupling of the test rack (**Figure 7**), and then couple the supply line to the Device end with regulating valve.

15.2.2.6 Open the supply cock and Cock 1. Cycle the valve several times by moving the Device handle from Position No. 1 to Position No. 6, finally leaving the handle in Position No. 1.

15.2.2.7 Verify that the Device reducing valve is set to close at **110 psi** (90 psi) as indicated by the test rack volume reservoir gauge. If the Device reducing valve does not close at **110 psi** (90 psi), then adjust the reducing valve to properly close at **110 psi** (90 psi).

> **NOTE:** If the pressure indicated on the test rack volume reservoir gauge should rise above **110 psi** (90 psi), then the Device ⅜ in. cock should be opened to release air trapped in the system. While the Device ⅜ in. cock is open, the reducing valve should be turned down below the set pressure. Once the reducing valve set point has been turned back down, close the Device ⅜ in. cock, and readjust the reducing valve. The pressure setting of the Device reducing valve shall be set by increasing to the set pressure and never by decreasing to the set pressure.

15.2.2.8 Move the Device handle to Position No. 6 and allow the test rack volume reservoir gauge to decrease to 0 psi, and then move the Device handle to Position No. 3 (Lap). Close Cock 1 and open the Device ⅜ in. cock. Coat the opening of the ⅜ in. cock with soap suds to detect rotary valve leakage to the brake pipe. Leakage must not exceed a 1 in. bubble in 5 seconds.

15.2.2.9 Close the ⅜ in. cock and move the Device handle to Position No. 6. Then coat the Device exhaust port with soap suds in Positions No. 6, 5, 4, 3, 2 and 1 consecutively. Leakage must not exceed a 1 in. bubble in 5 seconds.

15.2.2.10 With the Device handle in Position No. 1, open Cock 1. After the volume reservoir is charged to **110 psi** (90 psi), compare VOLUME RESERVOIR and DEVICE gauges and note that gauge hands register within ½ psi. Adjust DEVICE gauges if necessary.

15.2.2.11 FLOWRATOR Ball Test

a) Close the FLOWRATOR by-pass cock. There should be no indication of air flow. Open the FLOWRATOR by-pass cock and open Cocks 2 and 3, allowing air to vent through the choke fitting (or chokes) of the test rack.
b) Then close the FLOWRATOR by-pass cock. The ball should rise and float in the tube in the zone between the **110 psi** (90 psi) condemning line and the top of the tube.

NOTE: If the FLOWRATOR fails to pass this test, the ball and glass tube of the FLOWRATOR should be cleaned, using a non-residue-producing solution to remove any oil or foreign matter that may be carried into the Device. When the tube is properly installed in the FLOWRATOR cock, the dot on the tube should be below the condemning line.

15.2.2.12 Close cocks 2 and 3, and open the FLOWRATOR by-pass cock.

Wait a minimum of 45 seconds before commencing each of the following tests:

15.2.2.13 Move the Device handle to Position No. 4 and reduce the volume reservoir pressure to approximately 30 psi. Move the Device handle to Position No. 2. Note that the operating reservoir charges from 40 to 50 psi in **21.5 to 28.5 seconds** (27 to 33 seconds). At the completion of the test, move the Device handle to Position No. 1 and charge the reservoir to **110 psi** (90 psi).

a) Move the Device handle to Position No. 4. The volume reservoir pressure shall reduce from **100 to 50 psi** (80 to 50 psi) in **35 to 41 seconds** (24 to 26 seconds). At the completion of the test, move the Device handle to Position No. 1 and recharge to **110 psi** (90 psi).
b) Move the Device handle to Position No. 5. The volume reservoir pressure shall reduce from **100 to 40 psi** (80 to 40 psi) in **10 to 13 seconds** (7.5 to 9.5 seconds). At the completion of the test, move the Device handle to Position No. 1 and recharge to **110 psi** (90 psi).
c) Move the Device handle to Position No. 6. The volume reservoir pressure shall reduce from **110 to 40 psi** (80 to 20 psi) in **3 to 6 seconds** (4 to 7 seconds). At the completion of the test, move the Device handle to Position No. 1 and recharge to **110 psi** (90 psi).
d) Move the Device handle to Position No. 3 (Lap). Open the Device ⅜ in. cock and observe the test rack volume reservoir gauge to ensure that the volume reservoir pressure reduces from **110 to 20 psi** (90 to 20 psi) in **1.5 to 2.25 seconds** (1.5 to 2 seconds).
e) At the completion of the test, close the supply cock. Open the Device ⅜ in. cock, allow the gauge to decrease to zero (0) psi and close the Device ⅜ in. cock. Remove the Device from the test rack.

NOTE: If the measured times are long, then check for the proper choke size.

15.2.3 Test Procedure for Device Test Coupling on Standard Test Rack (Figure 6)

15.2.3.1 Move the Device handle to Position No. 1, open Cocks 1 and 2, and open the FLOWRATOR by-pass cock.

15.2.3.2 Close Cocks 4 and 5.

15.2.3.3 Open Cock 3.

15.2.3.4 Attach the test coupling to the FS-3 hose coupling located after Cock 5.

15.2.3.5 Charge the volume reservoir to 110 psi and wait 1 minute.

15.2.3.6 Move the Device handle to Position No. 3 and, with the FLOWRATOR by-pass open, open Cock 5 and observe that the volume reservoir gauge reduces from 106 to 101 psi within 2 minutes, 10 seconds, to 2 minutes, 29 seconds.

15.2.3.7 Close Cock 3 and wait until the flow of air from the 0.24 mm choke fitting stops.

15.2.3.8 Close Cock 5 and remove the test coupling.

15.2.3.9 If the choke fitting fails this test, then carefully replace the filter and blow the choke clean. Do not use metal tools to clean the choke. An appropriate cleaning solution may be used as needed. Once the choke is cleaned or replaced, repeat Section 15.2.3.

15.2.4 Test Procedure for Device Test Coupling on Alternate Test Rack (Figure 7)

15.2.4.1 Move the Device handle to Position No. 1, open Cock 1 and open the FLOWRATOR by-pass cock.

15.2.4.2 Close Cocks 3 and 4.

15.2.4.3 Open Cock 2.

15.2.4.4 Attach the FLOWRATOR end of the Device to the volume reservoir coupling of the test rack (**Figure 7**) then couple the supply line to the Device end with regulating valve. The air supply shall meet the requirements specified in Section 4.1.2.1.

15.2.4.5 Attach the test coupling to the FS-3 hose coupling located after Cock 4.

15.2.4.6 Charge the volume reservoir to 110 psi and wait 1 minutes.

15.2.4.7 Move the Device handle to Position No. 3 and, with the FLOWRATOR by-pass open, open Cock 4 and observe that the volume reservoir gauge reduces from 106 to 101 psi within 1 minutes, 9 seconds, to 1 minutes, 20 seconds.

15.2.4.8 Close Cock 2 and wait until flow of air from the 0.24 mm choke fitting stops.

15.2.4.9 Close Cock 4 and remove the test coupling.

15.2.4.10 If the choke fitting fails this test, then carefully replace the filter and blow the choke clean. Do not use metal tools to clean the choke. An appropriate cleaning solution may be used as needed. Once the choke is cleaned or replaced, repeat Section 15.2.4.

References

ASME B40.100 – "Pressure Gauges and Gauge Attachments", 2013

AAR Spec M-912 – "Oil, Control Valves", Adopted: 1941; Last Revised: 2002

AAR Spec M-914 – "Brake Cylinder Lubricant", Adopted: 1942; Last Revised: 2003

Definitions

Back-up mode: The EAB system being powered and active with microprocessors controlling and monitoring the functionality of the system.

Normal mode: The EAB system in an un-powered state with only pneumatic functionalities.

Abbreviations and acronyms

AAR	Association of American Railroads
ASME	American Society of Mechanical Engineers
BP	brake pipe
EAB	Electronic Air Brake
FRA	Federal Railroad Administration
min	minutes
MR	main reservoir
NATSA	North American Transportation Services Association
OR	Operating Reservoir
PC	Part Code
psi	pounds per square inch (short for psig unless otherwise specified)
psig	pounds per square inch gauge
s	seconds

Summary of document changes

- Document formatted to the new APTA standard format.
- Sections have been moved and renumbered.
- Scope and summary moved to the front page.
- Definitions, abbreviations and acronyms moved to the rear of the document.
- Two new sections added: "Summary of document changes" and "Document history."
- Some global changes to section headings and numberings resulted when sections dealing with references and acronyms were moved to the end of the document, along with other cosmetic changes, such as capitalization, punctuation, spelling, grammar and general flow of text.
- General – Change all gage to gauge. Webster Dictionary definition of gage does not agree with how it is used in this document.
- General - Removed the reference the troubleshooting.
- General – Added "TEST" step to where record should be made. Similar to AAR S-486. Bolded the statement.
- General – Added TEST in bold at the beginning of each step that required PASS/FAIL criteria.
- Keywords – Added 26-C and Brake Test.
- Scope – Updated dates to reflect latest revision.
- Scope – Broadened to include brake type equipment equivalent to 26-C.
- Scope – Added statement "must have M-005 in hand when requested by FRA."

- 1 – Electronic Air Brake Systems added as application.
- 2 – Removed date as all Devices should now be equipped as such.
- 2.1 – Added sentence about test coupling.
- 3.1 & 3.2 – Extended shelf life out to 1 year. Reworded the statement to agree with S-486 Section 2.2.
- 4.1.7 – Changed may to shall.
- 4.2.3 - The term “Cut Out” (CLOSED) was amended to also designate a cut-out cock that will stop the flow of air between equipment components.
- 4.2.4 & 4.2.5 – Added "Tests of car equipment shown herein may be performed in a different order than listed in this procedure provided that the conditions for the test, and the performance criteria described, are adhered to."
- 4.2.4 – Wording added to say "…. not identified or provided a test procedure within this…"
- 4.2.5 – Rewording of Section 4.2.5.
- 4.2.7 & 4.2.8 – Added Sections, renumbered original Section 4.2.7 to Section 4.2.9.
- 5.1.1 – Car motion changed to car movement.
- 5.2.3 – Added "Locomotive functions (service control of brake pipe) of cab cars shall be tested per current FRA regulations."
- 5.2.5 – Added "...equipment connected to the main reservoir shall…”
- 6.1.1 – Broken down into in to separate steps.
- 6.1.7 – Added new Section 6.1.7 and note.
- 6.1.8 – Added test step for verifying the 1" main reservoir check valve.
- 6.1.9 – Added new Section 6.1.9.
- 7.2 – Added all of Section 14.3 to Section 7.2 as a part of Main Reservoir Leakage.
- 7.2.2.6 – Added new Section 7.2.2.6.
- 8.1.1 – Changed pneumatically controlled to pneumatic cutoff valve.
- 8.2.1 – Changed BP reduction from 25 psi to 27 psi as 27 pound reduction ensures that a Full Service brake application is achieved for each test.
- 8.2.2 – Combined Section 8.2.2 “Allow 20 seconds settling time for brake cylinder pressure then note that brake cylinder pressure increases no more than 3 psi in 1 minute." with Section 8.2.1 and deleted the rest.
- 8.2.3 – Moved 20 second stabilization period to the beginning of the Section 8.2.3.
- 8.3 – Section 13 moved to Section 8.3.
- 8.3 – Added EAB statement.
- 8.3.1 – Change section title to Direct Release Test.
- 8.3.1.1 – Changed BP reduction from 25 to 27 as 27 pound reduction ensures that a Full Service brake application is achieved for each test.
- 8.5 – Combined Section 8.5 with Section 8.4 since the steps should be done sequentially.
- 8.5.2 – Use of general terms instead of control valve to cover electropneumatic systems
- 8.5.2 – Added "or by a reduction in brake cylinder as measured on the brake cylinder gauge."
- 8.5.4 – Removed all of Section 8.5.4 and renumbered Section 8.5.5 to 8.5.4.
- 9.1.2 – Changed BP reduction from 30 to 27 psi as 27 pound reduction ensures that a Full Service brake application is achieved for each test.
- 9.1.6 – Added Auxiliary after “last venting” in the first sentence and language for safely removing plugs.
- 9.2.1 – Added new Section 9.2.1.
- 9.2.3 – Changed BP reduction from 30 to 27 psi as 27 pound reduction ensures that a Full Service brake application is achieved for each test.
- 9.3 – Added sentence to say the brakes shall be in an emergency application before the start of this test.

- 9.3.1.1 – Combined with Section 9.3.1.
- 10 – Removed the wording of Port 10 and added 26-C 10 port and 16 exhaust.
- 10.1 – Added control valve leakage.
- 10.1 – Added EAB statement.
- 10.1.3 – Changed BP reduction from 26 to 27 as 27 pound reduction ensures that a Full Service brake application is achieved for each test.
- 10.1.3 & 10.2.4 – Added note to say that if it doesn't reach 50 psi then that is okay.
- 10.2 – Rearranged steps and added new step.
- 10.2.4 – Changed BP reduction from 26 to 27 as 27 pound reduction ensures that a Full Service brake application is achieved for each test.
- 10.2.6 – Added "or brake cylinder gauge."
- 11.2 - Turned it into Section 11.1.2.
- 12 – Added EAB statement.
- 12.1.2 – Changed BP reduction from 30 to 27 psi as 27 pound reduction ensures that a Full Service brake application is achieved for each test.
- 12.2.2 – Changed BP reduction from 30 to 27 psi as 27 pound reduction ensures that a Full Service brake application is achieved for each test.
- 13.1.2 – Changed from 25 to 27 psi as 27 pound reduction ensures that a Full Service brake application is achieved for each test.
- 14.6 – Added "Ancillary equipment should be Cut In for leakage test purposes."
- 14.6.2 – Added leakage test for ancillary equipment.
- 15 - Rewritten to combine **110** and (90) PSI versions.
- 16.1.1.1 – Added "This test is to be performed at least once each day of use." at the beginning of Section 16.1.1.1. Added "Close the 3/8" test cock." to the end of Section 16.1.1.1.
- Figure 6 and 7 – Updated the tables.
- Table 4 – Added K Triple, AB control, ABD control to the table and their respective documents to the table and APTA will have the documents available. Added this to the back of the publication as an appendix.
- Minor editorial changes made to 8.4.2 and 10.4.6 on December 17, 2020.

Document history

Document Version	Working Group Vote	Public Comment/ Technical Oversight	CEO Approval	Policy & Planning Approval	Publish Date
First published					June 15, 1998
First revision					May 5, 2003
Second revision					May 18, 2007
Third revision					June 30 2012
Fourth revision	August 31, 2017	September 30, 2017	October 14, 2017	July 25, 2018	July 27, 2018

Annex A – Equipment-Dependent Instructions

Please refer **Table 4** to determine which dated publication of Association of American Railroads Instruction Pamphlet No. 5039-4 Single Car Testing Device - Code of Tests is appropriate for the equipment being tested. Copies of these publications may be obtained from the APTA website.

TABLE 4
Equipment-Dependent Instructions

Equipment Type	Instruction Pamphlet No.	Date of Last Issue
D-22 Type Control Valve	5039-4, Sup 3	April 1, 1991
U-12-B Type Control Valve	5039-4, Sup 3	April 1, 1991
U-12 Type Control Valve	5039-4, Sup 1	November 1980
No. 3 Type Control Valve	5039-4, Sup 1	November 1980
L Type Triple Valve	5039-4, Sup 1	November 1980
P Type Triple Valve	5039-4, Sup 1	November 1980
*PS Type Triple Valve	5039-4, Sup 1	November 1980
K Triple Valve	5039-4, Sup 1	January 1956
AB Control Valve	5039-4, Sup 1	April 1, 1987
*PS does not refer to Electropneumatic overlay type equipment.		

- Equipment testing as described above may be done using Standard and Alternate Standard Testing Device as described in those publications
- Passenger cars equipped with AB Type Control Valves and newer freight-based brake systems shall be tested using equipment manufacturer/operating authority approved procedures in accordance with current Federal Regulations.
- For testing Conductor's Air Signal Equipment, please refer to the following publication: Conductor's Air Signal Instruction Leaflet No. 2377-2, July 1942

APTA STANDARDS DEVELOPMENT PROGRAM
STANDARD
American Public Transportation Association
1300 I Street, NW, Suite 1200 East, Washington, DC 20005

APTA PR-M-S-014-06, Rev. 1
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Wheel Load Equalization of Passenger Railroad Rolling Stock

Abstract: This *Standard* contains minimum requirements for wheel load equalization for non-articulated railroad passenger equipment of all types employing two axle trucks.

Keywords: equalization, suspension, wheel load equalization, wheel unloading

Summary: This standard establishes static wheel load equalization requirements to provide passenger equipment with the wheel unloading characteristics necessary to reduce the risk of low-speed wheel climb derailments. The *Standard* includes requirements for testing to verify compliance with the standard.

Scope and purpose: This standard shall apply to railroad passenger equipment of all types used in regular passenger service, originally contracted for after one year after authorized date. This includes locomotive-hauled cab and trailer cars, MU cars, and non-passenger-carrying cars and locomotives that are intended for use in passenger service on the general railroad system of the United States. This standard provides minimum requirements for wheel load equalization to reduce the risk of low-speed, wheel climb derailments.

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List of Figures and Tables

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Introduction

This introduction is not part of APTA PR-M-S-014-06, Rev. 1, "Wheel Load Equalization of Passenger Railroad Rolling Stock."

APTA recommends the use of this document by:

- individuals or organizations that operate rail transit systems;
- individuals or organizations that contract with others for the operation of rail transit systems; and
- individuals or organizations that influence how rail transit systems are operated (including but not limited to consultants, designers and contractors).

Wheel Load Equalization of Passenger Railroad Rolling Stock

1. Low-speed derailments

Several factors can contribute to low-speed derailments, including but not limited to the following:

- wheel flange angle
- coefficient of friction
- wheel load equalization
- truck rotational resistance
- track conditions (excessive warp, tight curvatures, gage face wear, etc.)
- vehicle dynamics
- operating conditions
- air spring suspension characteristics including deflated springs
- primary suspension characteristics

CAUTION: Experience indicates that low-speed derailments cannot be completely eliminated through equipment design alone. In addition to requiring specific vehicle characteristics, railroads must take a systems approach to minimizing the risk of low-speed derailment, which may require managing friction (providing rail lubrication) in tight curves, maintaining limits on rail gage face wear, and maintaining suitable levels of track cross level and other track parameters.

2. Wheel load equalization requirements

This standard provides upper limits on wheel unloading associated with one wheel being lifted or dropped with respect to the other wheels due to an extreme difference in cross level (DCL). These limits vary with the class of equipment, as described in Sections 2.1 through 2.4.

Sections 2.1 and 2.2 present upper limits on wheel unloading for vehicles having a pair of two-axle trucks. Sections 2.3 and 2.4 identify two other vehicle types, equipment with one or more three-axle trucks and equipment with shared axle trucks. Limits have not been established for these two equipment types. Limits will be set if the need arises in the future.

All passenger equipment shall be segregated into one of two suspension system classifications. Class G equipment (Section 2.1) is designed to operate over the general railroad system on track with DCL not exceeding 3 in. within any 62 ft of track. Current FRA regulations for track Class 1 permit a DCL of 3 in. within any 62 ft of track. Class R equipment (Section 2.2), while not equalizing as well as Class G, may be superior to Class G equipment with respect to other operating characteristics but requires the maintenance of track warp to a DCL not exceeding 2.25 in. in any 10 ft of track while still maintaining the Class G requirement of DCL not exceeding 3 in. within any 62 ft of track.

The choice of whether to qualify the vehicle as Class G or Class R will involve making a judgment as to the methodology to be used to meet the overall performance goals for the vehicle; Annex A discusses some of the factors to be considered in making this judgment.

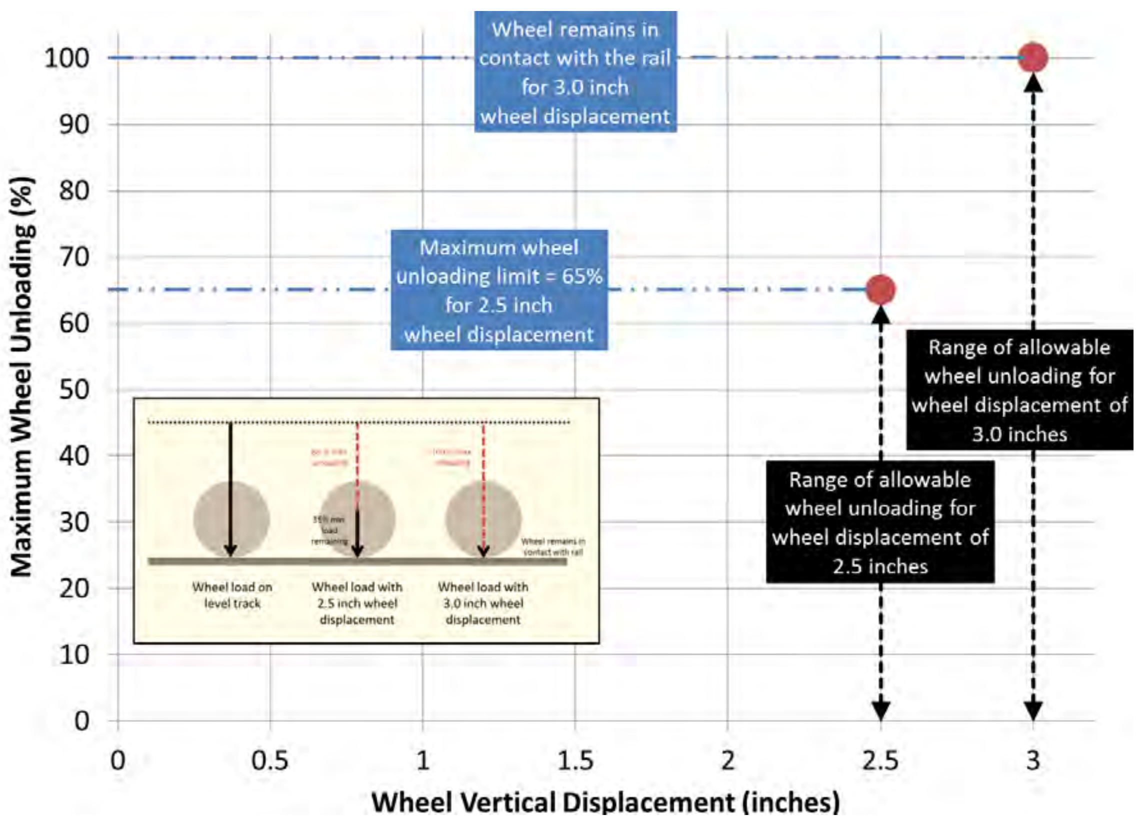
The equalization requirements specified in Sections 2.1 or 2.2 (whichever is appropriate) shall be confirmed by testing under specific conditions as described in Section 3.

2.1 Class G passenger equipment

> **NOTE:** The wheel unloading requirements in this section apply to passenger equipment with two-axle trucks that operates over track with a DCL upper limit of no more than 3 in. within any 62 ft. Dynamic condition wheel equalization (as obtained by vehicle dynamic analysis) takes into account long warp track condition for vehicle or truck-to-truck equalization.

For vehicles on level tangent track, vertical wheel loads shall be determined while displacing one wheel vertically (lift or drop) from its position on level track as depicted in **Figure 1**. At 2.5 in. of vertical wheel displacement, the wheel unloading shall not exceed 65 percent of the nominal wheel load. At all vertical wheel displacements up to and including 3.0 in., no wheel tread shall lose contact with the running surface of the rail.

FIGURE 1
Wheel Unloading Requirement–Class G



Testing and data reduction shall be done in accordance with Section 3. Hysteresis must be accounted for in testing.

In order to verify the wheel unloading requirements for Class G equipment, an analysis that is summarized in Annex B was conducted to evaluate the relationship between the static wheel unloading requirement and a dynamic wheel equalization scenario.

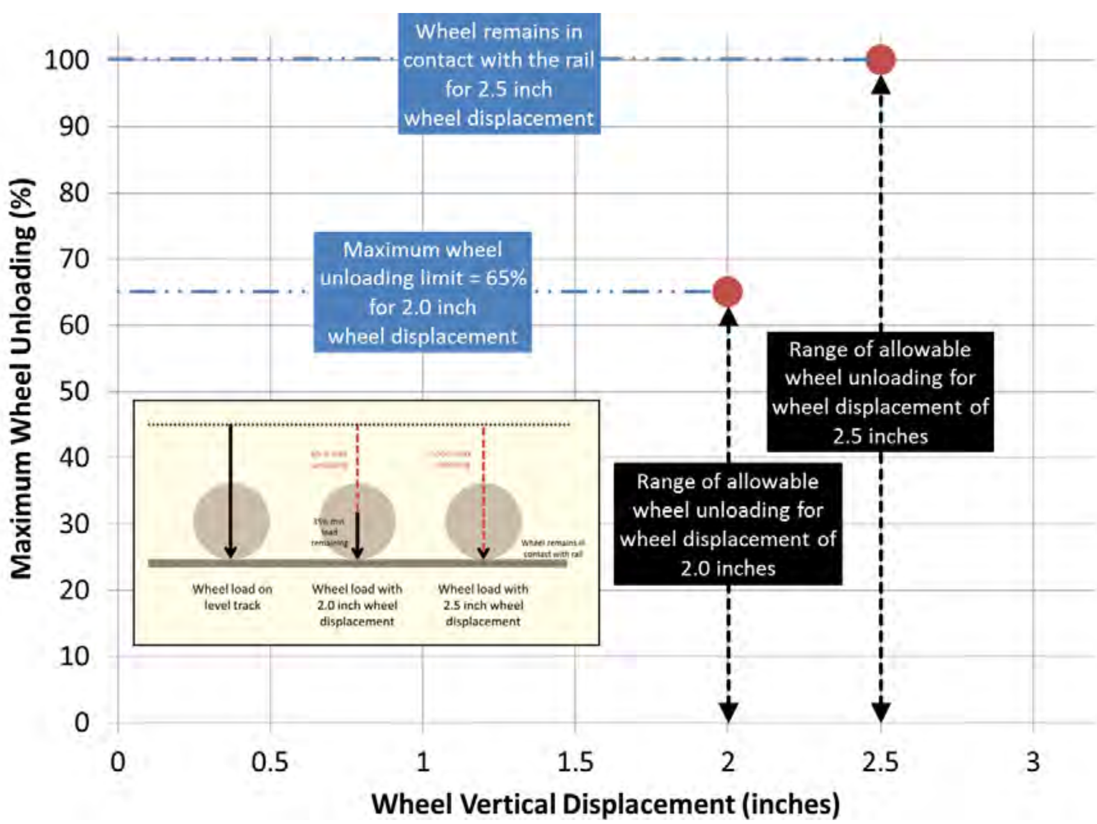
Equipment meeting Class G standards shall be stenciled on the inside of an equipment locker door (closest to the "B" end of the vehicle) "COMPLIES WITH APTA PR-M-S-014-06, CLASS G."

2.2 Class R passenger equipment

> **NOTE:** The wheel unloading requirements in this section apply to passenger equipment with two-axle trucks that operates over track with a DCL upper limit of no more than 2.25 in. over any 10 ft of track and no more than 3 in. within any 62 ft of track. Dynamic condition wheel equalization (as obtained by vehicle dynamic analysis) takes into account long warp track condition for vehicle or truck-to-truck equalization.

For vehicles on level tangent track, vertical wheel loads shall be determined while displacing one wheel vertically (lift or drop) from its position on level track as depicted in **Figure 2**. At 2.0 in. of vertical wheel displacement, the wheel unloading shall not exceed 65 percent of the nominal wheel load. At all vertical wheel displacements up to and including 2.5 in., no wheel tread shall lose contact with the running surface of the rail.

FIGURE 2
Wheel Unloading Requirement–Class R



Testing and data reduction shall be done in accordance with Section 3. Hysteresis must be accounted for in testing.

In order to verify the wheel unloading requirements for Class R equipment, an analysis that is summarized in Annex B was conducted to evaluate the relationship between the static wheel unloading requirement and a dynamic wheel equalization scenario.

> **CAUTION:** Equipment qualified under the provisions of this section and designated as Class R may at some time need to operate on track other than that for which it was acquired. This may occur during equipment delivery, special train movements or temporary detours. It will also occur if the equipment is sold for use in another service at a later date.

In any of these instances, notification of the Class R status of the equipment, together with information on where the equipment is to be operated, shall be submitted in writing to an appropriate official of the operating railroad, and confirmation of suitability for operation over the intended route(s) shall be obtained.

Equipment meeting Class R standards shall be stenciled on the inside of an equipment locker door (closest to the "B" end of the vehicle) "COMPLIES WITH APTA PR-M-S-014-06, CLASS R."

2.3 Passenger equipment with one or more three-axle trucks

> **NOTE:** The wheel unloading requirements in this section apply to passenger equipment intended for unrestricted operation and equipped with one or both trucks having three axles. If the need develops, this requirement will be addressed in a future revision.

2.4 Passenger equipment with articulated, shared axle trucks

> **NOTE:** The wheel unloading requirements in this section apply to passenger equipment intended for unrestricted operation and equipped with two independent axles having a wheel base greater than 15 ft. If the need develops, this requirement will be addressed in a future revision.

3. Static test

3.1 Test conditions

Conformance with the equalization requirements in Section 2 shall be verified by testing for the vehicle load and suspension conditions defined in **Table 1**.

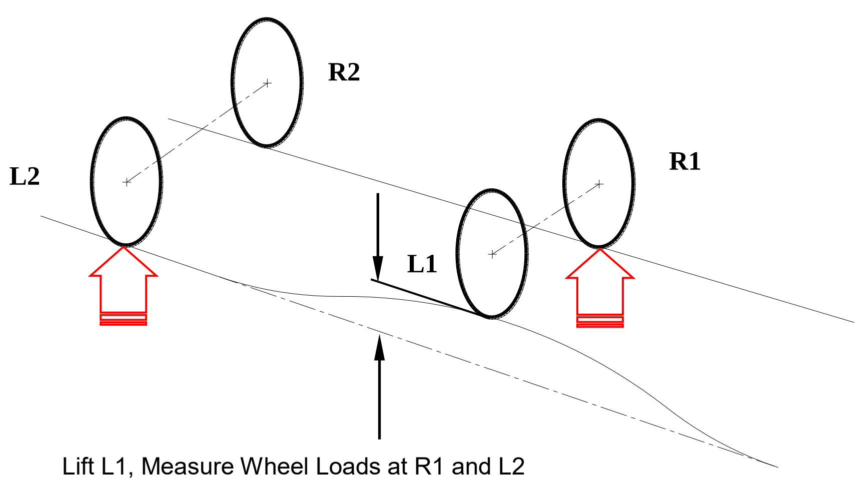
TABLE 1
Static Equalization Test

Parameter	Condition
Vehicle load[1]	AW0 if primary suspension is linear AW0 and AW3 if primary suspension is nonlinear[2]
Suspension	Normal operating[3]
Configuration	If the equipment contains trucks that are nominally the same with regard to equalization behavior, then only the more lightly loaded truck need be tested; otherwise, each truck design shall be tested.
Wheels to be tested[4]	Each wheel in turn on the test truck(s)
Wheel load measurement[3]	Wheel lift: Wheel load shall be measured on the wheel opposite the wheel lifted and on the wheel on the same side of the truck as the wheel lifted, as shown by arrows in **Figure 3**. Wheel drop: Wheel load shall be measured on the wheel dropped and on the wheel diagonally opposite the wheel dropped.

1. For locomotives, use 10 percent and 100 percent fuel load to represent partially and fully loaded cases, respectively.
2. It is recommended practice that an analysis be conducted to determine if an intermediate worst case vehicle loading condition exists between AW0 and AW3. This analysis should be conducted using a model validated by evaluating comparisons of simulation and test data for the AW0 and AW3 cases.
3. If air springs are used, then they are to be inflated with leveling valves disconnected.
4. All loads must be applied and measured at the wheel-rail interface.

The test shall be conducted in accordance with the procedure outlined in Section 3.2, and the analysis of the test data shall be performed in accordance with the method described in Section 3.3.

FIGURE 3
Measurement of Wheel Loads–Wheel Lifted



Lift L1, Measure Wheel Loads at R1 and L2

3.2 Test equipment and procedure

NOTE: This section outlines a test procedure that shall be used as a guide to conduct the static equalization test described in Section 3.1.

The following instrumentation and equipment can be used to conduct the static equalization test:

- load measurement devices (measure load between wheel and rail)
- lifting jacks of sufficient capacity
- track gage bar with cross level readout
- displacement measurement device (measure vertical displacement of wheel)

The test procedure shall require verification of the accuracy and ability of the load and displacement measurement devices to discriminate between compliant and noncompliant wheel unloading.

The test procedure outlined below should be used in conjunction with **Figure 3** and **Table 2**. The procedure is an example that describes the steps to be taken when lifting wheel L1 and measuring wheel loads at R1 and L2 as depicted in **Figure 3**. Measured wheel loads are entered into **Table 2** (for Class G).

1. Place test vehicle on straight, level track. Release brakes and back off slack adjusters. Chock wheels on truck not under test.
2. Establish test conditions as per Section 3.1 and note the wheel lift requirements per Section 2 for the class of equipment.
3. Measure and record the cross level adjacent to each axle of the vehicle using a suitable measurement device. All wheels must be within 1/16 in. of a "virtual" level rail plane established by all wheels on the car.
4. Lift wheel R1 and place the load measurement device between the wheel and rail. Zero the load measurement device before lowering the wheel. Repeat at wheel L2. The entire wheel load shall be supported by the load measurement device. In this condition, all wheels must be within 1/16 in. of a "virtual" level rail plane established by all wheels on the car.
5. Establish height of "virtual" level rail plane at wheel L1 for use as a baseline reference for determining the vertical displacement of the wheel during the test.
6. Record "zero height" static wheel loads at R1 and L2 (WL_{11}).
7. Lift wheel L1, by increments shown on **Table 2**. At each increment, record wheel loads at R1 and L2 (WL_{12} to WL_{15}).
8. Lower wheel L1, by increments shown on **Table 2**, back to the "zero height" condition. At each increment, record wheel loads at R1 and L2 (WL_{16} to WL_{19}).
9. Repeat steps 6 to 8 (i.e., second trial).

   NOTE: During second trial, wheel loads are designated (WL_{21} to WL_{29}).

   Performance of a second trial may not be warranted if the following criteria are met during the first trial:
   - Maximum wheel unloading is less than or equal to 55 percent at 2.5 in. of wheel displacement for Class G equipment.
   - Maximum wheel unloading is less than or equal to 55 percent at 2.0 in. of wheel displacement for Class R equipment.
   - The wheel unloading curves are as expected in terms of linear, nonlinear and hysteresis shape.
10. This process shall be repeated for each wheel of the truck.

3.2.1 Data reduction technique

NOTE: This section provides details for data reduction methods and practices to be used in the processing of static equalization test results for Class G and Class R equipment. The method takes into account the hysteresis effect that could be present in suspension arrangements.

The process is illustrated for one wheel, but this approach shall be applied for any other wheel tested and for any other test conditions.

For Class G equipment, **Table 2** depicts the method to be applied for recording measured wheel loads and the calculation of wheel unloading. The following bullets describe data entry and calculations for determining wheel unloading at wheel R1 when raising wheel L1 as shown on **Figure 3**:

- Measure and record wheel loads at wheel R1 (WL_{11} to WL_{19}) as wheel L1 is lifted, in increments from "zero height" up to 3 in. and then lowered back to level track. Repeat this process twice (WL_{21} to WL_{29}) (i.e., two trials).
- Determine the average wheel load (WL_2 to WL_5) based on wheel loads measured at Wheel R1, for both trials, at each incremental vertical displacement of Wheel L1.
- Determine the nominal wheel load (NWL) at Wheel R1 by averaging the wheel loads measured during the test when all wheels are on level track.
- Calculate the average wheel unloading at Wheel R1, at each vertical displacement, based on the average wheel load (WL_2 to WL_5) and the nominal wheel load (NWL). **Table 4** is an example of the calculation for Class G equipment.
- Repeat this measurement and calculation process for Wheel L2 as Wheel L1 is lifted.
- Repeat this entire process for the wheels at each corner of the truck.
  - Lift wheel L2; measure and calculate wheel unloading at wheels R2 and L1.
  - Lift wheel R2; measure and calculate wheel unloading at wheels R1 and L2.
  - Lift wheel R1; measure and calculate wheel unloading at wheels R2 and L1.

TABLE 2

Wheel Unloading Calculation Form – Class G

Wheel L1 Lifted	Measured Wheel Load R1 (lb)		Average Wheel Load R1 (lb)					Average % Unloading Wheel R1
	Trial 1	Trial 2	*3 (in)*	*2½ (in)*	*2 (in)*	*1 (in)*	*0 (in)*	
0 (in)	WL_{11}	WL_{21}						
1 (in)	WL_{12}	WL_{22}				**WL_2**		$\frac{(NWL - WL_2)}{NWL}$
2 (in)	WL_{13}	WL_{23}			**WL_3**			$\frac{(NWL - WL_3)}{NWL}$
2½ (in)	WL_{14}	WL_{24}		**WL_4**				$\frac{(NWL - WL_4)}{NWL}$
3 (in)	WL_{15}	WL_{25}	**WL_5**					$\frac{(NWL - WL_5)}{NWL}$
2½ (in)	WL_{16}	WL_{26}						
2 (in)	WL_{17}	WL_{27}						
1 (in)	WL_{18}	WL_{28}						
0 (in)	WL_{19}	WL_{29}					**NWL**	

Example @ 1 (in)

$(WL_{12}+WL_{22}+WL_{18}+WL_{28}) / 4 = WL_2$

Example @ 0 (in)

$(WL_{11}+WL_{21}+WL_{19}+WL_{29}) / 4 = NWL$

NOTE: For Class G equipment at 2.5 in. of wheel lift, wheel unloading per truck corner, based on the lifting of that corner's wheel, shall be computed by measuring the unloading of the remaining wheels, averaging the unloading per each wheel for two consecutive trials, and retaining the highest average. This unloading per truck corner shall not exceed 67 percent. The average of all four truck corner wheel unloadings shall not exceed 65 percent.

Table 3 depicts the method for Class R equipment.

TABLE 3

Unloading Calculation Form–Class R

Wheel R1 Load Equalization (L1 Lifted)

Wheel L1 Lifted	**Measured Wheel Load R1** (lb)		**Average Wheel Load R1** (lb)				**Average % Unloading Wheel R1**	***Wheel L1 Lifted***
	Trial 1	**Trial 2**	***2½*** *(in)*	***2*** *(in)*	***1*** *(in)*	***0*** *(in)*		
0 *(in)*	WL_{11}	WL_{21}						
1 *(in)*	WL_{12}	WL_{22}			$\mathbf{WL_2}$		$\frac{(NWL - WL_2)}{NWL}$	***1*** *(in)*
2 *(in)*	WL_{13}	WL_{23}		$\mathbf{WL_3}$			$\frac{(NWL - WL_3)}{NWL}$	***2*** *(in)*
2½ *(in)*	WL_{14}	WL_{24}	$\mathbf{WL_4}$				$\frac{(NWL - WL_4)}{NWL}$	***2½*** *(in)*
2 *(in)*	WL_{15}	WL_{25}						
1 *(in)*	WL_{16}	WL_{26}						
0 *(in)*	WL_{17}	WL_{27}				**NWL**		

Example @ 3/4 (in)

$(WL_{12}+WL_{22}+WL_{16}+WL_{26}) / 4 = WL_2$

Example @ 0 (in)

$(WL_{11}+WL_{21}+WL_{17}+WL_{27}) / 4 = NWL$

NOTE: For Class R equipment at 2.0 in. of wheel lift, wheel unloading per truck corner, based on the lifting of that corner's wheel, shall be computed by measuring the unloading of the remaining wheels, averaging the unloading per each wheel for two consecutive trials, and retaining the highest average. This unloading per truck corner shall not exceed 67 percent. The average of all four truck corner wheel unloadings shall not exceed 65 percent.

TABLE 4

Wheel Unloading Calculation Example–Class G

Wheel R1 Load Equalization (L1 Lifted)

Wheel L1 Lifted	Measured Wheel Load R1 (lb) Trial 1	Measured Wheel Load R1 (lb) Trial 2
0 (in)	16,103	16,101
1 (in)	12,487	12,610
2 (in)	8,371	8,619
2-1/2 (in)	6,164	5,486
3 (in)	3,019	2,560
2-1/2 (in)	7,250	6,644
2 (in)	9,418	9,921
1 (in)	13,555	13,890
0 (in)	17,691	17,700

Average Wheel Load R1 (lb)				
3 (in)	*2-1/2 (in)*	*2 (in)*	*1 (in)*	*0 (in)*
2,789.5	6,386.0	9,082.3	13,135.5	16,898.8

Average % Unloading Wheel R1	*Wheel L1 Lifted*
22.3%	*1 (in)*
46.3%	*2 (in)*
62.2%	*2-1/2 (in)*
83.5%	*3 (in)*

Example @ 1 (in)

(12,487+12,610+13,555+13,890) / 4 =13,135.5

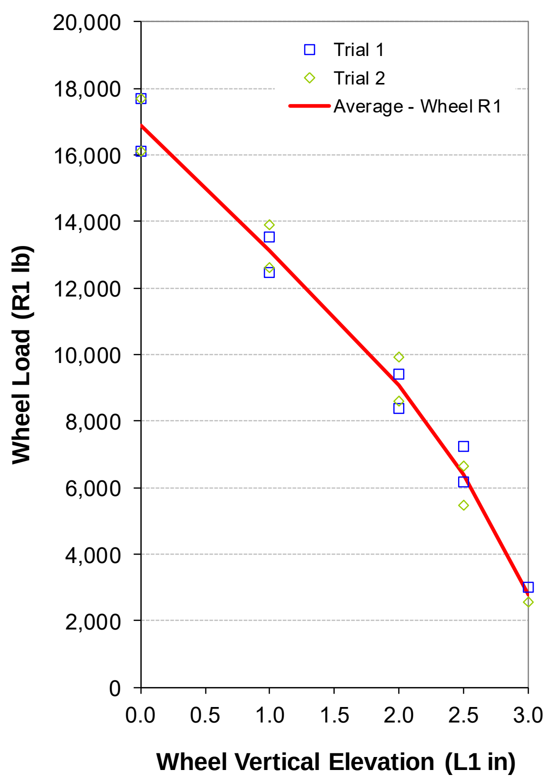
Example @ 0 (in)

(16,103+16,101+17,691+17,700) / 4 = 16,898.8

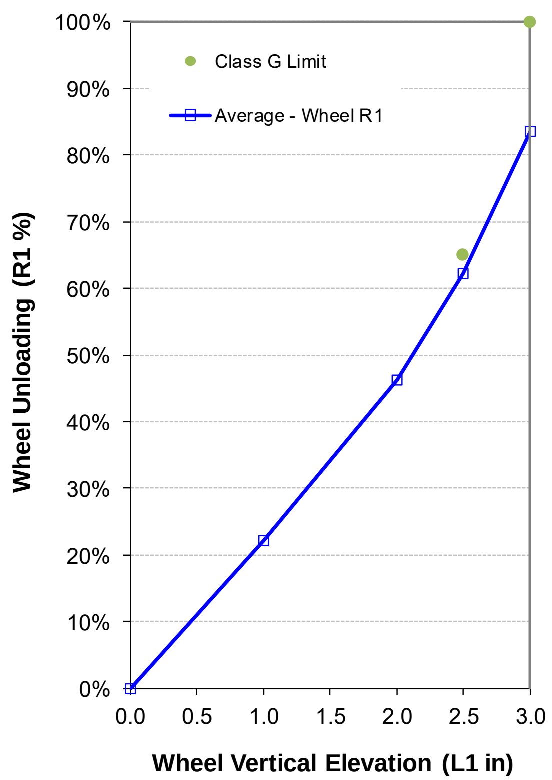
Example @ 2-1/2 (in)

(16,898.8-6,386.0) / 16,898.8 = 62.2%

Wheel Load (R1 lb)



Wheel Unloading (R1 %)



NOTE: For Class G equipment at 2.5 inches of wheel lift – Wheel unloading per truck corner, based on the lifting of that corner's wheel, shall be computed by measuring the unloading of the remaining wheels, averaging the unloading per each wheel for two consecutive trials, and retaining the highest average. This unloading per truck corner shall not exceed 67%. The average of all four truck corner wheel unloadings shall not exceed 65%.

TABLE 4 (continued)

Wheel Unloading Calculation Example–Class G

Wheel R1 Load Equalization (L1 Lifted)

Wheel L1 Lifted	**Measured Wheel Load R1** (lb) **Trial 1**	**Trial 2**
0 *(in)*	16,103	16,101
1 *(in)*	12,487	12,610
2 *(in)*	8,371	8,619
2-1/2 *(in)*	6,164	5,486
3 *(in)*	3,019	2,560
2-1/2 *(in)*	7,250	6,644
2 *(in)*	9,418	9,921
1 *(in)*	13,555	13,890
0 *(in)*	17,691	17,700

Average Wheel Load R1 (lb) ***3*** *(in)*	***2-1/2*** *(in)*	***2*** *(in)*	***1*** *(in)*	***0*** *(in)*
2,789.5	**6,386.0**	**9,082.3**	**13,135.5**	**16,898.8**

Example @ 1 (in)

(12,487+12,610+13,555+13,890) / 4 =13,135.5

Example @ 0 (in)

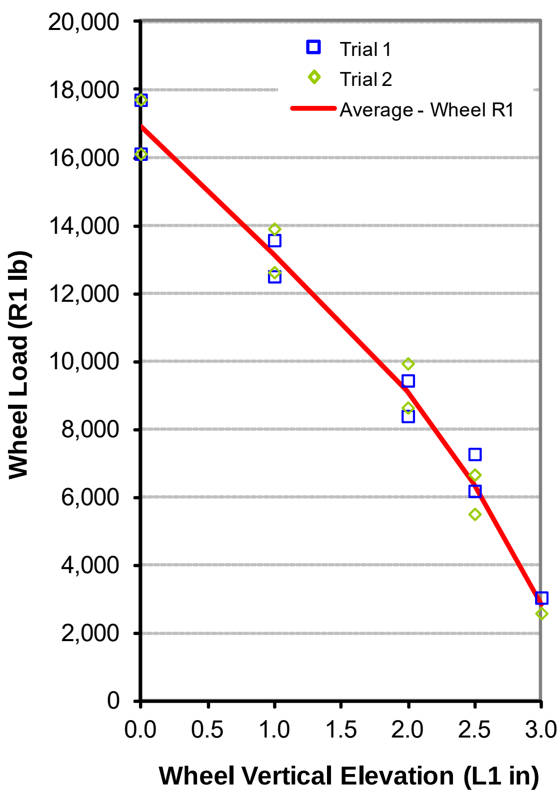
(16,103+16,101+17,691+17,700) / 4 = 16,898.8

Average % Unloading Wheel R1	***Wheel L1 Lifted***
22.3%	***1*** *(in)*
46.3%	***2*** *(in)*
62.2%	***2-1/2*** *(in)*
83.5%	***3*** *(in)*

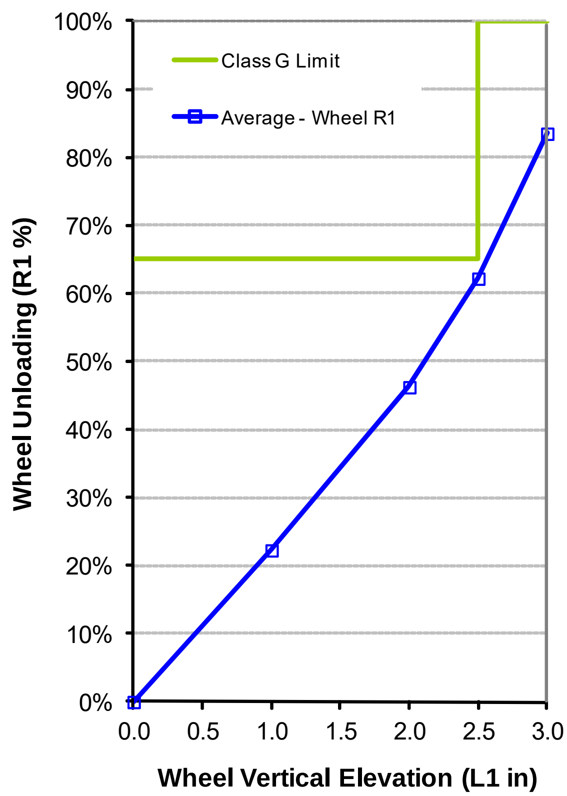
Example @ 2-1/2 (in)

(16,898.8-6,386.0) / 16,898.8 = 62.2%

Wheel Load (R1 lb)



Wheel Unloading (R1 %)



NOTE: For Class G equipment at 2.5 inches of wheel lift – Wheel unloading per truck corner, based on the lifting of that corner's wheel, shall be computed by measuring the unloading of the remaining wheels, averaging the unloading per each wheel for two consecutive trials, and retaining the highest average. This unloading per truck corner shall not exceed 67%. The average of all four truck corner wheel unloadings shall not exceed 65%.

Related APTA Standard

APTA PR-M-S-015-06, "Wheel Flange Angle for Passenger Railroad Rolling Stock."

Reference

49 CFR 213 Code of Federal Regulations – Track Safety Standards.

Definitions

cross-level: The difference in height or elevation of one rail with respect to the other rail at any cross-section. On tangent track, the difference in height is measured with respect to a horizontal line. On super-elevated track, it is measured with respect to a line across the top of rails, with the height difference equal to super-elevation.

difference in cross-level (DCL): The difference in cross level between any two cross-sections along the track.

equalization (wheel load equalization): Describes the degree to which a vehicle maintains uniform vertical wheel loads over vertical track irregularities. As used in this standard, equalization refers to this measure under static conditions. For example, a measure of the equalization capability of a vehicle is the increase or decrease in vertical wheel loads when a single wheel is either above or below a uniform track plane established by the remaining wheels. The lower the change in vertical load associated with a track rise or dip, the better the equalization. Dynamic condition wheel equalization (as obtained by vehicle dynamic analysis) takes into account long warp track condition for vehicle or truck-to-truck equalization.

general railroad system of the United States: Encompasses all railroad systems, both freight and passenger, under the authority of the United States Federal Railroad Administration (FRA), as enacted by the Federal Railroad Safety Authorization Act of 1994, that must adhere to the rules and regulations set forth in the Code of Federal Regulations, Title 49 Transportation

hysteresis: Mechanical energy loss that occurs under cyclical loading and unloading of suspension systems.

linear suspension system: The vertical force versus deflection behavior of a suspension spring system that follows a linear relationship throughout its design deflection range, such that a simple linear equation can represent deflection characteristics.

long warp: Warp measured at a distance equal to or greater than the distance between truck centers.

nominal wheel load (NWL): The vertical load on the rail from a wheel when measured on level tangent track, with all the wheels of the vehicle in the same plane and the vehicle stationary.

non-linear suspension system: The vertical force versus deflection behavior of a suspension spring system that departs from a linear relationship within the design deflection range, such that a simple linear equation does not represent deflection characteristics.

short warp: Warp measured between any two points within 10 ft along a section of track.

truck warp: Warp measured relative to one of the four wheels of a two-axle truck with respect to the plane generated by the wheel-rail contact patches of the other three wheels.

truck wheelbase: The longitudinal distance between the two axle centers on a two-axle truck.

warp: The maximum difference in cross-level measured at a specified chord distance, such as 62 ft, taken along a segment of track.

wheel load (WL): Vertical load of the wheel on the rail.

wheel unloading (WUL): Wheel load difference as a percentage of NWL:

$$WUL = \{(NWL - WL)/NWL\} \times 100$$

Abbreviations and acronyms

APTA	American Public Transportation Association
FRA	Federal Railroad Administration
DCL	difference in cross level
NWL	nominal wheel load
PRESS	Passenger Rail Equipment Safety Standards
WL	wheel load
WUL	wheel unloading

Summary of document changes

Primary revisions were made to address the effects of different passenger loadings on load equalization performance.

- Addition of reference
- Revised **Figure 1** and **Figure 2** to improve clarity.
- Added AW3 loading and corresponding note for nonlinear suspension springs. Added corresponding note in Section 3.1 regarding analysis of intermediate loadings.
- Added note in Section 3.1 for locomotive loading cases based on fuel load.
- Added note regarding potential effects of deflated springs in Section 1.
- Added text to Section 3.2, step 9, allowing fewer tests if performance thresholds are met.
- Added definition of general railroad system.
- Added definitions of linear and nonlinear suspensions
- Updated standard numbering scheme and revised contributor list.

Document history

Document Version	Working Group Vote	Public Comment/ Technical Oversight	CEO Approval	Policy & Planning Approval	Publish Date
First published	—	—	—	May 18, 2007	June 2, 2007
First revision	Dec. 23, 2015	April 4, 2016	March 23, 2017	May 1, 2017	June 1, 2017

Annex A (informative): Wheel load equalization

This annex provides background information discussing the role of wheel load equalization in contributing to derailment risk, and it describes some of the tradeoffs that may arise in suspension system design for good equalization and for good performance in other areas. This annex is informative and does not contain requirements that must be evaluated for demonstrating compliance to this standard.

General

Adequate equalization, together with management of other factors, is important for safe operation of rail equipment, including minimizing the risk of low-speed derailment. Equalization is controlled to a large extent by the vehicle's suspension system. Suspension stiffness, geometry and other factors determine the equalization capability of the vehicle.

The track surface irregularity referred to as difference in cross level (DCL) is the parameter of concern as regards equalization. Wheel unloading caused by DCL will increase the risk of low-speed derailment, although other factors are likely to be present and be contributing factors in causing the derailment. Low-speed derailment can occur without wheel unloading provided other factors are present; wheel unloading simply reduces the margin of safety against derailment.

Inertial (dynamic) effects will influence wheel unloading. Typical parameters that control the magnitude of this component of wheel unloading are vehicle speed, rate of change of lift or drop with distance along the track and the slope of this rate of change. These are predominant parameters that determine whether or not the vertical load change approaches static. The dynamic response of the vehicle to track irregularity is also a factor, which may influence whether or not the wheel vertical load change is approximated as static.

Low-speed derailment is typically classified as either wheel climb or rail rollover derailment. Factors that contribute to wheel climb derailment are vertical and lateral load at the interface between wheel and rail, angle of attack of the wheel with the rail against which the wheel is being driven by the lateral load, friction coefficient between wheel and rail, wheel flange geometry and rail gage face geometry. Rail rollover derailment is sensitive to vertical and lateral wheel load and to rail anchorage to the ties or slab base. In either type of derailment, equalization can play a significant role through its influence on vertical wheel load.

The ratio of lateral force to vertical force acting at the wheel-to-rail contact patch of a wheel is a predominant parameter in establishing the risk of low speed derailment resulting from wheel climb. The critical value of this ratio is related to coefficient of friction between wheel and rail and to the maximum angle that the flange makes with the horizontal (the flange angle). The magnitudes of the vertical and lateral forces occurring in operation are functions of DCL, equalization, unbalance on curves, yaw moment between truck and carbody, and possibly other factors such as buff and draft loads at the couplers. When these factors result in a ratio of lateral to vertical force greater than the critical value, and the distance and/or time over which the ratio remains high is sufficient, wheel climb derailment can occur.

The vehicle's suspension affects equalization by creating resistance of the wheelsets to developing roll angles independently of one another within a truck when subjected to short warp DCL. A second mechanism affecting wheelset load change is associated with roll of one truck that transmits a torsional moment between trucks through the carbody; this moment will result in a variation of vertical load fractions carried by the wheels on both trucks. These two components of equalization, referred to as truck warp and truck-to-truck equalization, may both play a significant role in equalization or one may dominate.

> **NOTE:** In the context of this document, the term truck warp refers to "out of plane" deformation rather than the parallelogram distortion which may occur in freight truck applications

Short wavelength DCL on the order of wheelset spacing within a truck, sometimes referred to as short warp, will typically result in truck warp being the dominant component affecting equalization for passenger car and locomotive suspension arrangements. The relative roles of the truck warp and truck-to-truck components may be reversed for freight car suspension arrangements, due to the relatively good truck warp equalization of the three-piece freight car truck and the relatively stiff vertical suspension of freight cars as compared with passenger cars and locomotives. Relatively long-wavelength DCL, on the order of truck spacing, will typically result in truck-to-truck equalization being the dominant equalization component. One potential source for long-wavelength DCL is transition in super-elevation when entering or exiting curves (spiral transition).

Maximum static wheel unloading will occur either when one wheel experiences a vertical displacement with the other wheels of the truck remaining in the plane established for level track or when two diagonally disposed wheels experience a vertical displacement with respect to the two wheels on the other diagonal. In the former case, both the truck warp and truck-to-truck components of wheel unloading will be present, while in the latter case only the truck warp component will be present. However, the latter case can be expected to produce a truck warp component of wheel unloading equal to that in the former case at approximately one-half the height change of the two diagonally disposed wheels as was experienced by one wheel in the former case. Therefore, rate of change of profile of either rail with distance would be less severe in the latter case than in the former case in order to result in the same truck warp component of wheel unloading in both cases.

Rolling stock design with good equalization capability will lower derailment risk over the range of operating conditions encountered in most, if not all, operations. However, there are tradeoffs associated with design for good equalization. The user must determine whether the track and other conditions on its system will permit equalization capability to be outside the limits set by this standard while still retaining acceptably low low-speed derailment risk. Even with equalization meeting the limits specified in this standard, low-speed derailment risk will be acceptably low only if the other influencing factors are controlled. It is the user's responsibility to manage all factors that contribute to low-speed derailment in order to operate with acceptably low risk.

Operating conditions in addition to those listed above that may increase derailment risk are the following:

- cant excess on curves
- spiral curve entry and exit
- buff and draft forces on vertical and horizontal curves
- traction and braking forces and moments generated in right-angle mechanical drives

Suspension system design tradeoffs

The vehicle suspension system, in addition to establishing wheel load equalization performance, has an influence on other vehicle characteristics that in turn affect overall performance. Suspension system design determines ride quality and wheel-rail interface dynamic loads. Suspension system design influences wayside noise and vibration, static steering on curves, high-speed stability, dynamic envelope, roll stability and wheel load shifts due to cant deficiency. Suspension system design for controlling the performance measures delineated above may force limits on the level of wheel load equalization that can be achieved.

Truck maintenance and weight considerations may be in conflict with suspension design for controlling the performance measures mentioned above.

Therefore, in order to manage both low-speed derailment risk and other aspects of suspension system performance, it may be prudent to consider tighter limits on track irregularities (DCL in particular).

Annex B (informative): Static wheel unloading vs. likelihood of low-speed derailment

The load equalization standard is in part based on simulations investigating the potential for vehicle derailment as a function of static unloading performance. These calculations were intended to address the following questions:

- How do static jacking test results correlate with the potential for derailment over track twist inputs?
- What level of static jacking performance is required to avoid derailment?

The simulations modeled a generic four-axle car representative of a typical North American passenger coach. Calculations were performed using VAMPIRE®, a generalized multi-body simulation for rail vehicle applications. VAMPIRE® is a UK-registered trademark of DeltaRail Group Ltd.

Static jacking results were calculated using the VAMPIRE® Static Analysis program. Wheel unloading was obtained by lowering a single-wheel on one truck. The calculation is equivalent to a static jacking test on a full vehicle. Both wheel-to-wheel (truck) and truck-to-truck (vehicle) equalization are considered. Given symmetry of the vehicle, the calculations were performed for a single wheel only. All other wheels would effectively provide the same result.

The dynamic calculations considered a hypothetical low-speed derailment scenario. The track input was a 300-foot radius curve without super-elevation. The tight curve causes significant wheel-rail lateral forces and a high angle of attack at truck leading axles. A track dip on the curve outside rail then creates a loss of vertical load on that rail. The combination of a high angle of attack and a single wheel L/V ratio exceeding the Nadal criterion makes derailment likely.

The perturbation shape was defined by a versine as shown in **Figure 4**. The data points in the figure correspond to field measurements taken in an experiment determining possible track bump waveforms. The fit between the assumed waveform and the measurements is quite good.

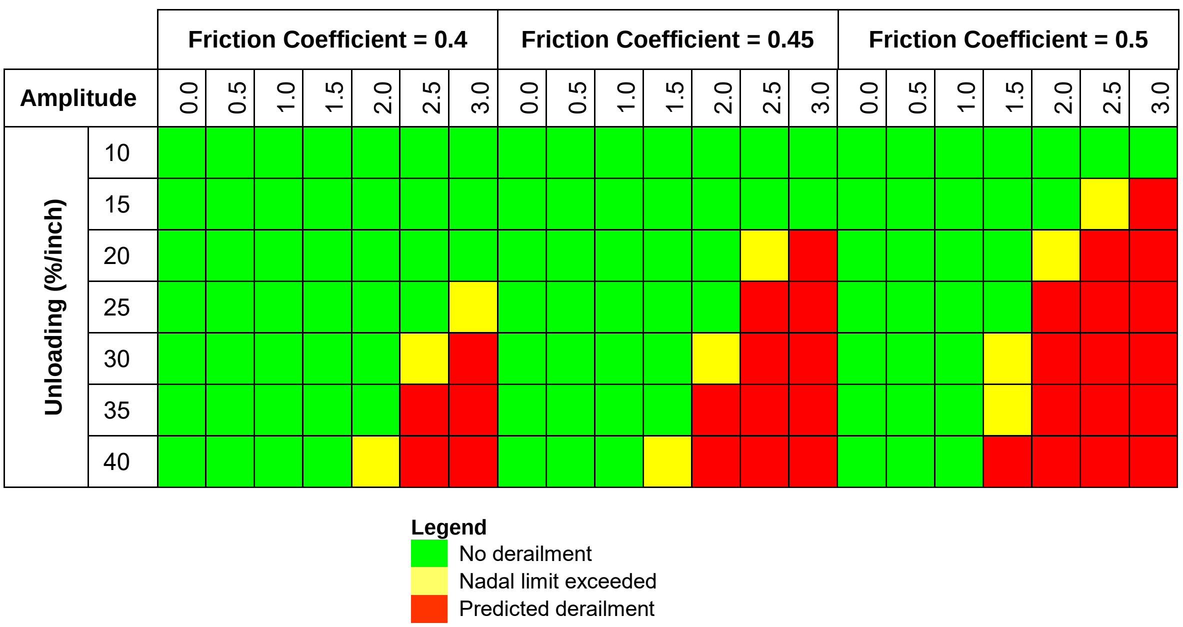
FIGURE 4
Track Dip Input

Vehicle dynamic response was predicted using the VAMPIRE® Transient Analysis program. The calculations considered track dip amplitudes ranging from 0.5 to 3 in. Vehicle speed was 5 mph. Previous calculations up to 15 mph indicated the low-speed case was critical. The vehicle wheel profile was a nominally worn contour with a constant 1:20 tread taper and a 72 deg. flange. Wheel-rail friction coefficients from 0.4 to 0.5 were assumed at both tread and flange contact.

Qualitative simulation results are summarized in **Table 5**. The results are divided into three categories. First is the case where derailment was not predicted and maximum single wheel L/V ratios did not exceed the Nadal limit. Second are cases where derailment was not predicted but maximum single wheel L/V ratios did exceed the Nadal limit. The final case is where derailment was predicted. That is, VAMPIRE® predicted one or more wheels would climb up and over the outside rail of the curve.

As shown, input amplitudes of 2.5 in. or more invariably lead to derailment at friction coefficients greater than 0.4 or static unloading performance worse than 25 percent per inch. A friction coefficient of 0.5 leads to derailment over track dips of 2.0 in. or greater unless static unloading performance is 10 percent or better.

TABLE 5
Summary of Simulation Results



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Commuter, Intercity and High-speed Rail Mechanical Working Group

Safety Appliances for Passenger Equipment

Abstract: This standard establishes requirements for safety appliance design, installation and maintenance for passenger equipment including non-passenger-carrying locomotives.

Keywords: attachment, collision post handhold, crew handhold, end handhold, handbrake, handrail, ladder, roof handhold, safety appliance, side door handhold, side door step, sill step, sill step handhold, uncoupling device

Summary: This standard provides detailed requirements for the application, installation, maintenance, repair and replacement of safety appliances for passenger equipment including non-passenger-carrying locomotives.

Scope and purpose: This standard applies to new tier I, II and III passenger equipment, with initial procurement contract awarded on or after one year after publication of the newest revision, for use on the general railroad system of the United States and Canada. This standard is intended for only newly made passenger equipment but does not prevent application to rebuilt or overhauled passenger equipment. In the event of discrepancy between the text of this standard and the illustrations, the text shall govern. APTA developed this standard to enhance the operational safety of new passenger equipment by recognizing modern analytical techniques and manufacturing methods and to provide clarity and uniformity in the application of safety appliance regulations. APTA intends to petition the Federal Railroad Administration (FRA) and Transport Canada to incorporate this standard in total or by reference into the appropriate rules and regulations. If that happens, changes to existing contracts resulting in financial burdens caused by this standard should be handled through the established FRA and Transport Canada waiver/exemption processes.

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Introduction

This introduction is not part of APTA PR-M-S-016-06, Rev. 1, "Safety Appliances for Passenger Equipment."

This standard applies to all:

1. railroads that operate intercity or commuter passenger train service on the general railroad system of transportation; and
2. railroads that provide commuter or other short-haul rail passenger train service in a metropolitan or suburban area, including public authorities operating passenger train service.

This standard does not apply to:

1. rapid transit operations in an urban area that are not connected to the general railroad system of transportation;
2. tourist, scenic, historic or excursion operations, whether on or off the general railroad system of transportation;
3. operation of private cars, including business/office cars and circus trains; or
4. railroads that operate only on track inside an installation that is not part of the general railroad system of transportation.

APTA undertook the development of this standard for application to passenger equipment that do not neatly fall into the traditional federal regulations contained in 49 CFR Part 231 governing safety appliances. 49 CFR 231 contains three different passenger car types in parts 231.12 (Passenger-train cars with wide vestibules), 231.13 (Passenger-train cars with open-end platforms) and 231.14 (Passenger-train cars without end platforms). Modern equipment designs do not follow these specific car configurations. Today's passenger railroads have introduced and operate multi-level cars, cars with center boarding, cab cars, married pairs, cars with no vestibules, semi-permanently connected trainsets, etc. These new car types do not easily fit into the three passenger car types defined in the regulation.

Additionally, APTA and its members worked collaboratively with FRA as part of the regulatory changes to 49 CFR 238 under the Engineering Task Force as part of FRA's Rail Safety Advisory Committee. Revisions to this standard also consider the discussions and consensus language developed as part of this effort.

The intent of this standard is to provide clarity in the design, manufacturing, installation, inspection, maintenance, repair and replacement of safety appliances for various passenger equipment. The standard clearly defines the function of each type of safety appliance and gives detailed requirements on the dimensions, material, location and manner of attachment. Appendix A of this standard includes a compliance checklist that railroads, and car builders can use to ensure compliance with the standard. This checklist can also be part of the basis for a sample car inspection if conducted.

APTA patterned the standard after the Association of American Railroads' Standard AAR S-2044, covering freight car safety appliances. The AAR has petitioned FRA to incorporate the freight car safety appliance standard into the federal regulations.

APTA intends similarly to petition the FRA and Transport Canada to incorporate this standard into the federal regulations.

Safety Appliances for Passenger Equipment

1. Coordinate system and units of measurement

The following figures show the coordinate system used in this standard. This coordinate system is used to be consistent with FRA and AAR terminology. **Figure 1** shows coordinates in relation to safety appliances. **Figure 2** shows coordinates in relation to passenger equipment.

FIGURE 1
Safety Appliance Coordinate System

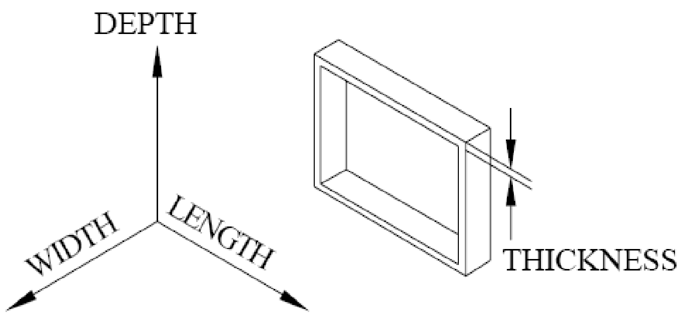
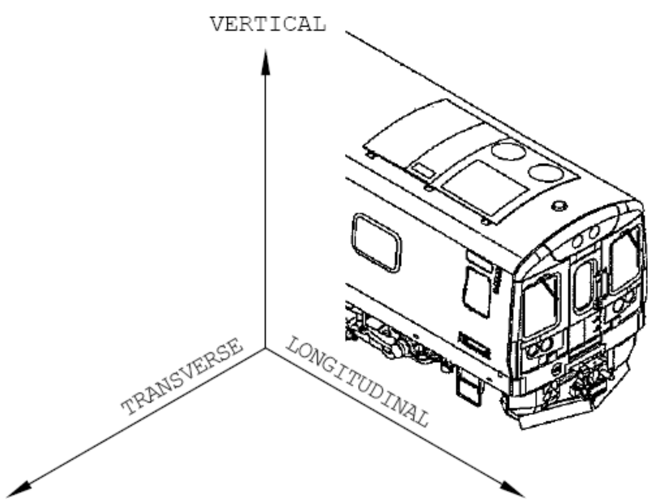


FIGURE 2
Passenger Equipment Coordinate System



Vertical dimensions defined relative to the top of rail are to be based on new wheels, ready to run, empty car conditions.

Units of measurement used in this standard are US customary units. These are followed by their rounded equivalents in International System (SI) units, enclosed in parentheses. The first value stated shall be regarded as the requirement.

2. General requirements

2.1 General

Safety appliances applied to cars shall be designed, manufactured, installed, inspected, maintained, repaired and replaced in accordance with the requirements of this standard. The design of safety appliances shall not violate the railroad's clearance diagram and shall account for vehicle manufacturing tolerances.

> **NOTE:** APTA recommends that railroads and carbuilders consider designing to dimensions greater than the minimums and less than the maximums contained in this standard to allow for manufacturing tolerances and other minor deviations.

2.2 Purpose

Safety appliances aid railroad employees or contractors in performing their duties safely by providing a means to support and/or stabilize themselves while riding equipment, entering or leaving equipment, inspecting equipment, coupling/uncoupling equipment, or setting handbrakes.

2.3 Materials and processes

All sill steps, side door steps, ladders, handrails and handholds shall be made of wrought iron or steel with minimum yield strength of 25,000 psi (173 MPa). Stainless steel of equivalent strength may be used. Steel safety appliances may be cast, rolled, forged or made by any other process that provides the required strength.

Alternate materials may be used if the safety appliance is evaluated in accordance with Section 2.4.2. This equivalency would also be subject to approval by the purchasing authority.

To allow for standard mill tolerances, actual sizes of components (material thickness, diameter, etc.) may be 5% below the nominal sizes. Clearance dimensions are minimum dimensions (−0%).

2.4 Strength and rigidity requirements

All handrails, handholds, ladders, side door steps and sill steps shall meet the strength and rigidity requirements of this section by demonstrating compliance with either of the following two methods:

1. For strength purposes, safety appliances shall meet the dimensions as follows:
    a. For handrails, handholds and ladders, they must be made of ⅝ in. (16 mm) diameter steel.
    b. For sill steps and crew access steps, a rectangular cross-section shall be used, with a minimum cross-sectional area of ½ in. (12.7 mm) thick by 2 in. (50.8 mm) wide steel. Alternate sections may be used if they meet the strength and rigidity of a ½ in. (12.7 mm) thick by 2 in. (50.8 mm) wide steel section.
    c. Sill steps and crew access steps exceeding 18 in. (457 mm) in depth shall have an additional tread and be transversely (laterally) braced.
    d. Handholds exceeding 60 in. (1524 mm) in length shall be securely fastened with at least two fasteners at each end.
2. Alternatively, safety appliances may be designed to comply with the following minimum design loads. For purposes of evaluation, the load may be distributed over a distance of not more than 3 in. (76 mm) along the usable length of the safety appliance. The design loads shall be supported in all directions as follows:
    a. Handholds shall be designed to support a load of 350 lb (1557 N) at any point on the usable length of the handhold in any direction and shall be rigidly attached to the carbody structure such that the maximum elastic deflection at the midpoint of an unsupported span under 50%

of the applied 350 lb (1557 N) load shall be no greater than L/120, where L is the unsupported length of the span.

b. Steps shall be designed to support individually applied loads at any point on the usable length of 450 lb (2002 N) in the vertical (±) direction and 350 lb (1557 N) in any horizontal direction (± transverse or ± longitudinal) such that the maximum elastic deflection at the midpoint of an unsupported span under 50% of the applied loads shall be no greater than L/120, where L is the unsupported length of the span.
c. Stresses in the safety appliance and the car structure to which it is attached shall be less than the specified minimum yield strength for each component for the load values given in paragraphs 2.a. and 2.b.
d. Fillet welds, if used, and fasteners shall be designed to have an ultimate strength with a factor of safety of at least two with respect to the load values give in paragraphs 2.a. and 2.b..
e. The safety appliance and the connection to the carbody to which it is attached shall be designed for infinite fatigue life (10 million cycles) based upon the service vibration environment and the mass of the safety appliance. If the intended service environment is undefined, the accelerations listed in Table 1 may be used for the evaluation. If the connection is part of the carbody as defined in Section 2.5.2, then the connection to the carbody is exempt from the fatigue evaluation.

TABLE 1
Fatigue Loads for Service Environment

Orientation	Acceleration
Vertical	±0.25 g
Transverse	±0.20 g
Longitudinal	±0.15 g

2.5 Manner of application

1. All safety appliances shall be securely fastened to the carbody structure using one of the following methods:

    a. **Mechanical fasteners.** Safety appliance mechanical fasteners shall have mechanical strength and fatigue resistance equal to or greater than a ½ in. (12.7 mm) diameter fastener conforming to one of the following specifications:
        i. Carbon/low alloy steel: SAE J429 Grade 5 bolt (English units) or ISO 898-1, Grade 8.8 (metric units).
        ii. Stainless steel: ASTM F593, Groups 1–3, Condition CW1 (English units) or ISO 3506-1, Grades A2-70 or A4-70, Condition CW (metric units).

    If providing safety appliances in accordance with Section 2.4.1, the size of fasteners used shall be ½ in. (12.7 mm) diameter.

    Threaded fasteners must be secured by one of the following methods:

        i. Self-locking feature, including locknut and locking bolt that meet the prevailing torque requirements for locking fasteners specified by the Industrial Fastener Institute for the applicable grade and size fastener used.
        ii. Locking device that provides the minimum prevailing first removal torque value for locking fasteners specified by the Industrial Fastener Institute for the applicable grade and size fastener used.

iii. Wedge-locking washers consisting of two symmetrically designed washers that have inclined ramps on the sides in mutual contact and non-slip contact surfaces on the sides in contact with the nut and work piece. Washer and nut or bolt arrangements utilizing similar locking principles are also acceptable.
iv. Lock washers that meet the requirements for lock washers specified by the Industrial Fastener Institute for the applicable grade and size fastener used.
v. Locking tab, cotter pin, or safety wire that restricts rotation of the bolt, nut or both.

One- or two-piece rivets or swaged lock fasteners similar to Huck®[1] bolts may be used without additional locking features.

b. **Welded safety appliances.** Welded safety appliances and connections, when used, shall have the following qualities:
i. Designed and fabricated in accordance with the welding process and the quality control procedures contained in the applicable current American Welding Society Standard, the Canadian Welding Bureau Standard, or an equivalent nationally or internationally recognized welding standard.
ii. Welded by an individual possessing the qualifications to be certified under the applicable current American Welding Society Standard, the Canadian Welding Bureau Standard, or an equivalent nationally or internationally recognized welding qualification standard.
iii. Inspected by an individual qualified to determine that the welding has been performed in accordance with the requirements in paragraph (b)(ii) of this section.
iv. Repairs to welded safety appliances and connections shall meet the requirements contained in paragraphs (i)–(iii) of this section.
v. Welded safety appliances and safety appliance subassemblies shall be welded in accordance with paragraphs (i)–(iii) of this section.
vi. Structural members or brackets welded in accordance with paragraphs (i)–(iii) and meeting the strength requirements in Section 2.4.2, "Strength and rigidity requirements," shall be considered part of the carbody structure.

2. Brackets and supports. For safety appliances provided in accordance with Section 2.4.1, brackets or supports to which safety appliances are fastened are considered part of the carbody if they can support the load requirements applied to the safety appliances as defined in Section 2.4.2 with a factor of safety of 2 against yield strength.

3. Inspection. All appliances and support members shall, as far as practicable, be installed to facilitate inspection of all attachments, fasteners or welds.

3. Safety appliance requirements

3.1 Parking brake system

3.1.1 General

Any individual car that is not semi-permanently connected to an adjacent car and any set of semi-permanently coupled cars must be equipped with a parking brake. Semi-permanently coupled cars shall have a minimum of one location to set and release the parking brake.

Tier III trainsets may be equipped with an alternative means of securing the equipment as in compliance with 49 CFR 238.731(o).

[1] Huck®, a registered Trademark of Howmet Aerospace Inc.

3.1.2 Purpose/function

The parking brake is used to apply force mechanically to one or more brake shoes or pads on the car.

3.1.3 Location

3.1.3.1 General

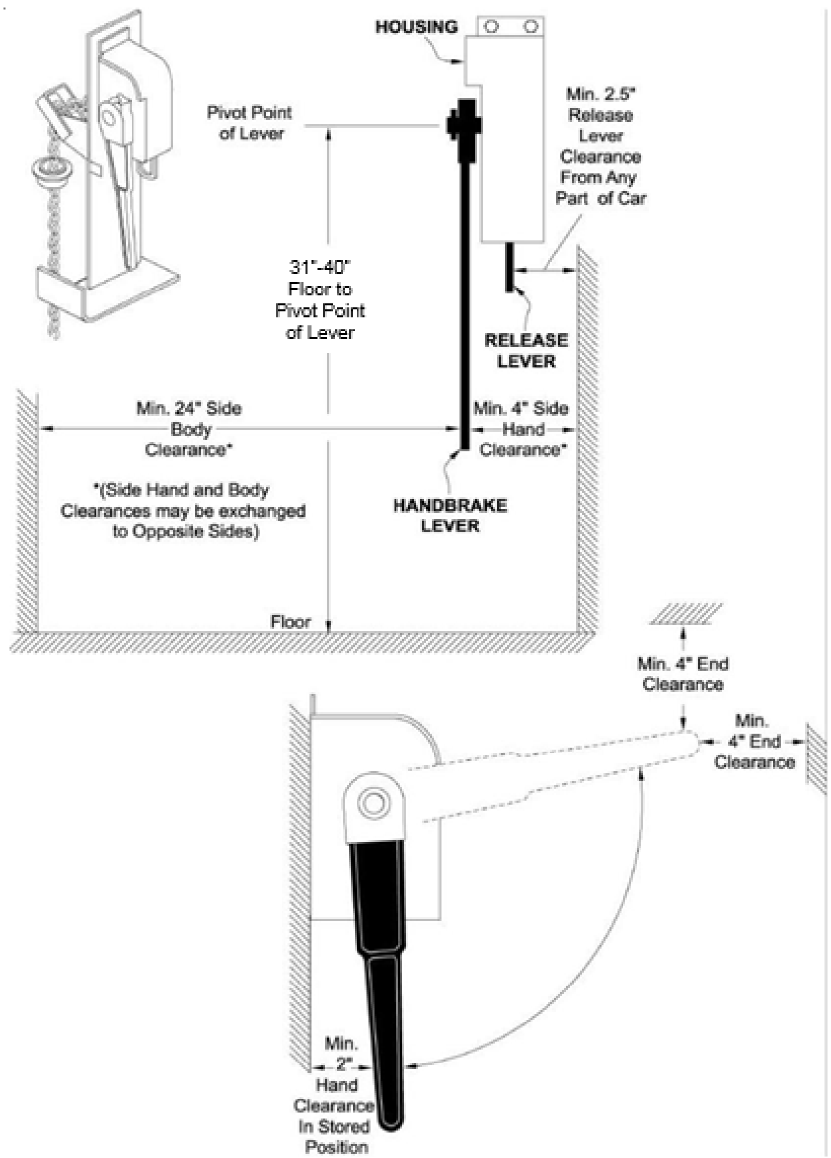
1. The handbrake as installed shall be located so as to not restrict passenger flow through any passageway. The handbrake handle, whether applied or released, and in its stored position, shall not restrict passenger flow through any passageway.
2. The handbrake shall be located so it can be safely operated while the car is in motion.
3. A handhold shall be provided to stabilize an employee when using the handbrake. The handhold shall have a minimum 2 in. (51 mm) hand clearance.

3.1.3.2 Handbrake, lever type

1. The center point of the pivot point of the lever used to apply the handbrake shall be located 31 to 40 in. (788 to 1016 mm) above the floor.
2. Any handbrake handle retention mechanism shall not interfere with the normal grip position of the lever.
3. The handbrake release lever shall have a minimum 2 in. (51 mm) hand clearance in the operating position.
4. The handbrake lever shall have a minimum 2 in. (51 mm) hand clearance in the stored position, a 24 in. (610 mm) body clearance on one side of the lever, and a minimum 4 in (102 mm) hand clearance on the opposite side and end in the operating position.
5. The clearance between the grip portion of the release lever, if used, and any part of the car shall be no less than 2½ in. (64 mm).

See **Figure 3**.

FIGURE 3
Lever Type Handbrake

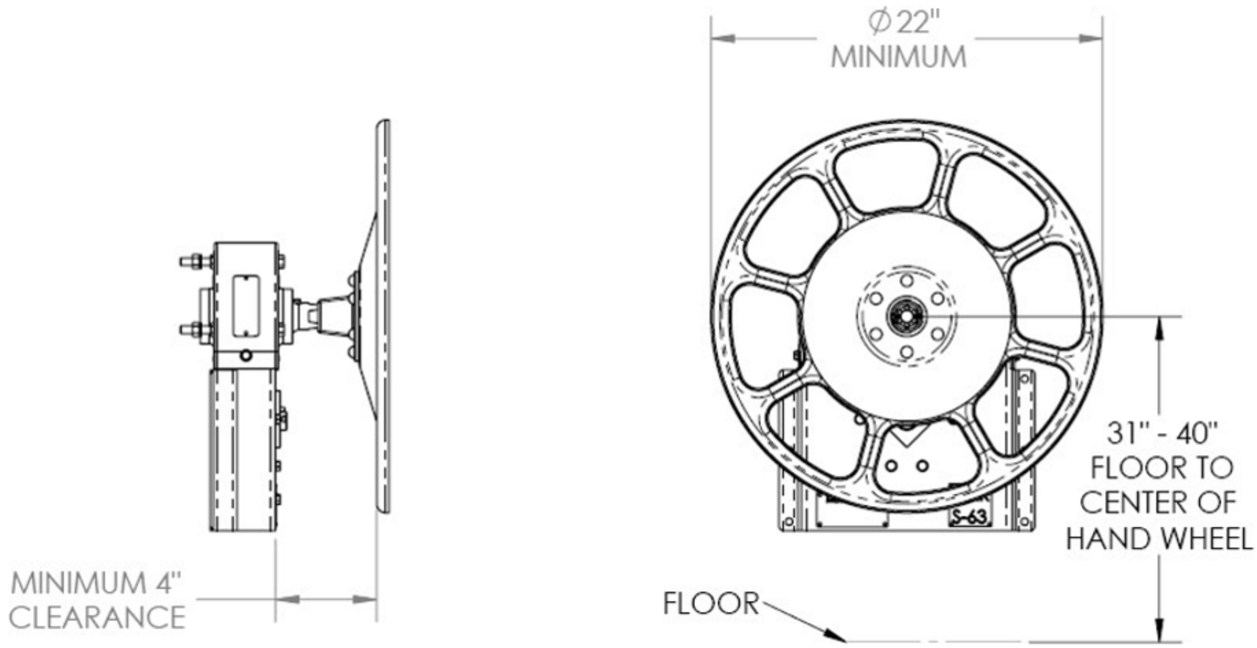


3.1.3.3 Handbrake, wheel type

1. The center point of the wheel shall be located 31 to 40 in. (788 to 1016 mm) above the floor.
2. The wheel type handbrake shall have a minimum 4 in. (102 mm) hand clearance.
3. The wheel diameter shall be at least 22 in. (559 mm).

See **Figure 4**.

FIGURE 4
Wheel Type Handbrake



4. If equipped, the hand brake manual release lever shall have a minimum 2 in. (51 mm) hand clearance.

3.1.3.4 Power-assisted applied/release parking brake

A readily accessible operational control mechanism and manual release lever shall be provided.

3.1.4 Manner of application for wheel or lever handbrake type

The handbrake housing must be securely fastened. Bolts used for mounting the handbrake shall be designed to resist the maximum chain force with a minimum factor of safety of 2. The maximum chain force is that developed by the handbrake mechanism when a 125 lb (556 N) force is applied 3 in. (77 mm) in from the end of the application lever, typically 20 to 24 in. (508 to 609 mm) long, or on the rim of a handbrake wheel unless the design of the mechanism restricts the applied force to a lower value.

Handbrake mounting brackets are to be securely fastened, preferably with mechanical fasteners. Bell crank mounting brackets, sheave wheel mounting brackets, brake rod supports and guides, and chain supports and guides are not considered safety appliances, and hence are not subject to the manner of application requirements in this standard. See **Figure 3** and **Figure 4** for typical handbrake applications.

3.2 Crew provisions to ride

3.2.1 General

Sill steps and associated handholds are required at each end of passenger equipment equipped with an automatic coupler, unless the following applies:

1. For the leading and the trailing cab ends of semi-permanently coupled passenger cars or passenger trainsets.
2. A crew member who performs switching operations is able to ride safely inside the cab or on a crew or passenger access doorway/step and has an unobstructed view of the track ahead for that crew member.
3. Cab/control ends of self-propelled passenger equipment with fully automatic couplers.

3.2.1.1 Purpose/function

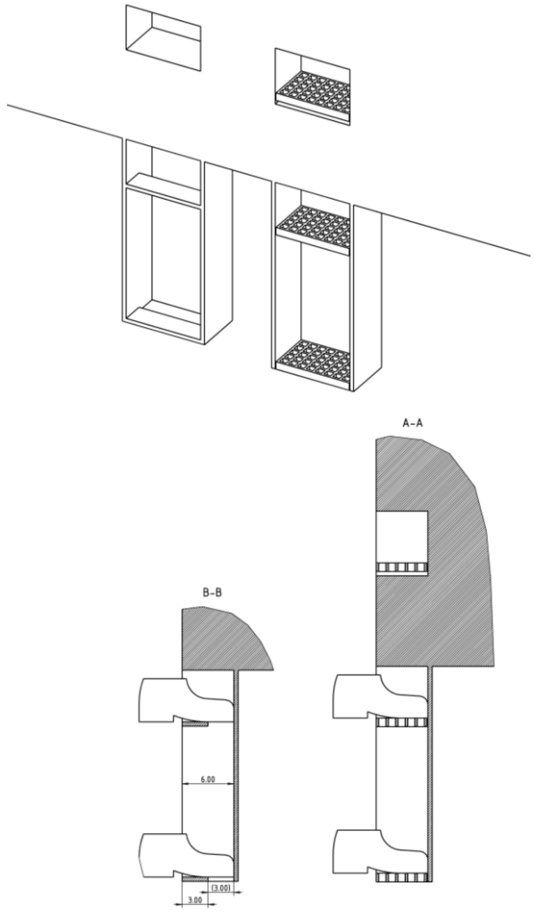
1. Sill steps allow an employee to ride on the side, near the end of the car during switching moves.
2. Sill step handholds are used to stabilize an employee while riding on the sill step.

3.2.2 Sill steps

3.2.2.1 Dimensions for sill steps

1. The minimum usable length of tread shall be not less than 10 in. (254 mm), preferably 12 in. (305 mm).
2. Sill steps shall be no less than 2 in. (51 mm) wide.
3. The clear depth above the entire usable length of the sill step tread shall be no less than 8 in. (204 mm). For Tier III trainsets, the value for clear depth may be reduced to 4.7 in. (120 mm). The clear width of all sill step treads shall be no less than 6 in. (153 mm) with the trucks rotated to simulate the maximum curvature specified for the uncoupled car. (See **Figure 25** in “Definitions” for clear depth and clear width definition.)
4. Sill steps shall not have a vertical rise between treads exceeding 18 in. (457 mm).
5. The portion of the tread surface area of each sill step that is normally contacted by the foot shall be treated with an anti-skid material or be slip-resistant by texturing of the metal surface in such a way that it lasts the life of the car. Some examples of acceptable methods are diamond plate and stamped, upset or expanded metal. For enclosed step designs, at least 50% of the tread area shall be open space. See **Figure 5** for open space examples.

FIGURE 5
Enclosed Step Open Space Examples



6. To account for minor deviations, the application of sill steps shall be such that a box with the dimensions shown in **Table 2** can pass through the opening above the sill step to the point where the box is flush with the outer edge of the step.

TABLE 2
Sill Step Box Dimensions

	Box Length	Box Depth	Box Width
Sill step	10 in. (254 mm)*	8 in. (204 mm)	6 in. (153 mm)
Sill step (Tier III)	10 in. (254 mm)*	4.7 in. (120 mm)	6 in. (153 mm)

* Box Length Preferably 12 inches (305 mm)

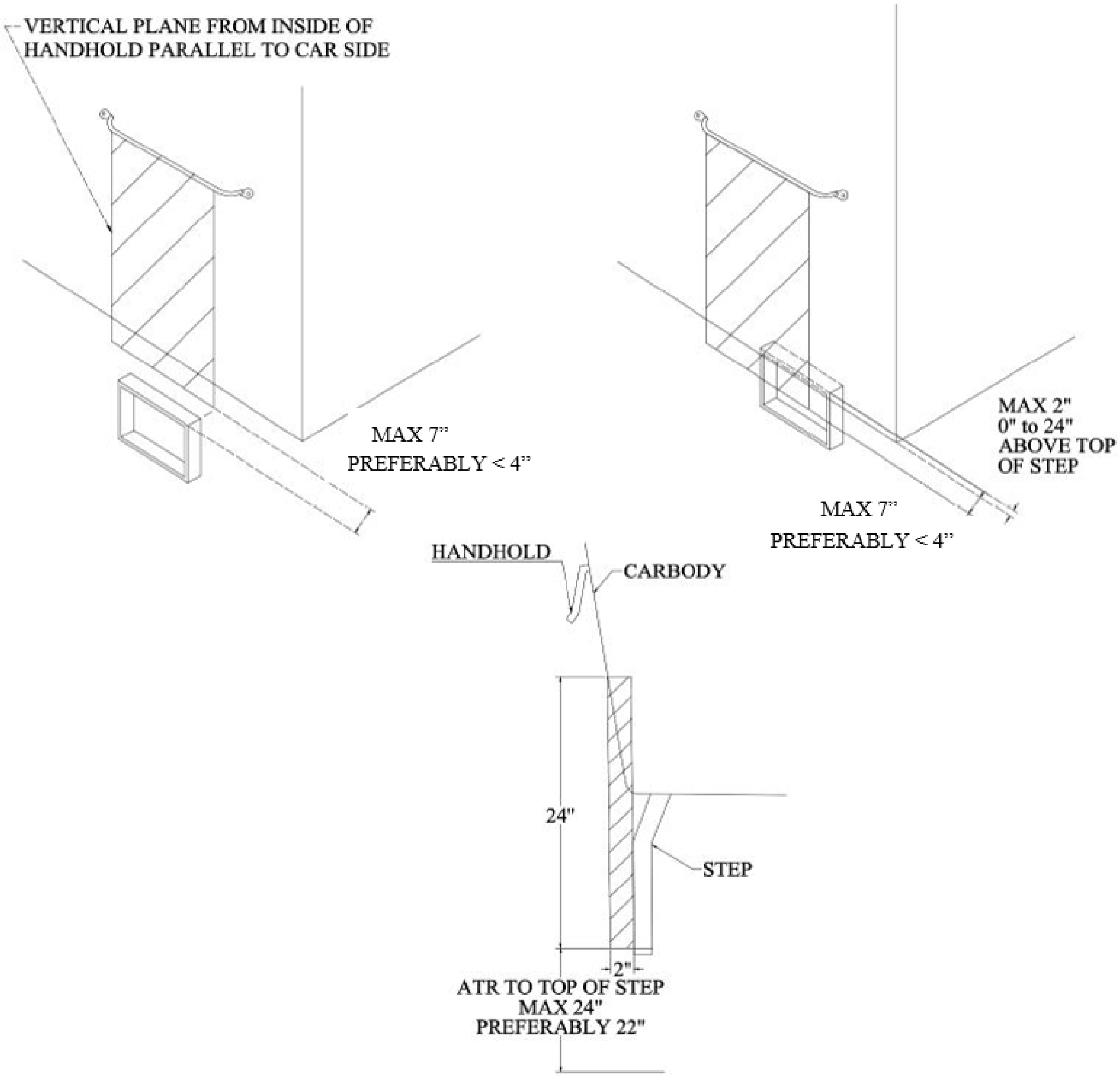
3.2.2.2 Location

1. One sill step shall be applied at each corner of the car. A passenger step may be used in lieu of a sill step if it meets the clear depth, clear width, usable length and location requirements for a sill step.
2. The outboard end of the usable length of the sill step shall be not more than 18 in. (457 mm) in the longitudinal direction from the corner of the car. For cars without well-defined corners, the intent is

for the sill step to be positioned for the employee to have an unobstructed view of the track ahead. The sill step shall be placed so the employee has a clear view in both longitudinal directions and shall be placed outside the gauge of the track.

3. The sill step tread shall be not more than 24 in. (609 mm), preferably not more than 22 in. (558 mm), above the top of rail. The design goal is to have the tread of the sill step as close to the top of rail as the clearance diagram permits.
4. The outside edge of any sill step tread shall be no more than 2 in. (50 mm) inboard of any car structure or additional steps within 24 in. (610 mm) directly above the clear length of the step. A maximum of 4 in. (101 mm) is permitted for sill step treads at or below 21 in. (534 mm) above the top of rail, provided it is otherwise not possible to remain within the clearance diagram. The design goal is to have the outside edge of the sill step tread to be as flush with the side of the car as the clearance diagram permits. See **Figure 6**.
5. Coordination of step to handhold in transverse direction: The outside edge of any sill step tread shall be a maximum 7 in. (177 mm), preferably less than 4 in. (101 mm) inboard or outboard of the inside surface of the lowest adjacent side handhold clear length. The design goal is to have the outside edge of the sill step tread to be aligned with the sill step handhold as the clearance diagram permits.

FIGURE 6
Schematic View of Sill Step in Transverse Direction



3.2.3 Sill step handholds

3.2.3.1 Dimensions for sill step handholds

Handholds shall be no less than ⅝ in. (16 mm) in diameter. Minimum clear length of handholds shall be 16 in. (406.4 mm). Minimum clearance shall be 2 in. (51 mm), preferably 2½ in. (64 mm).

3.2.3.2 Location

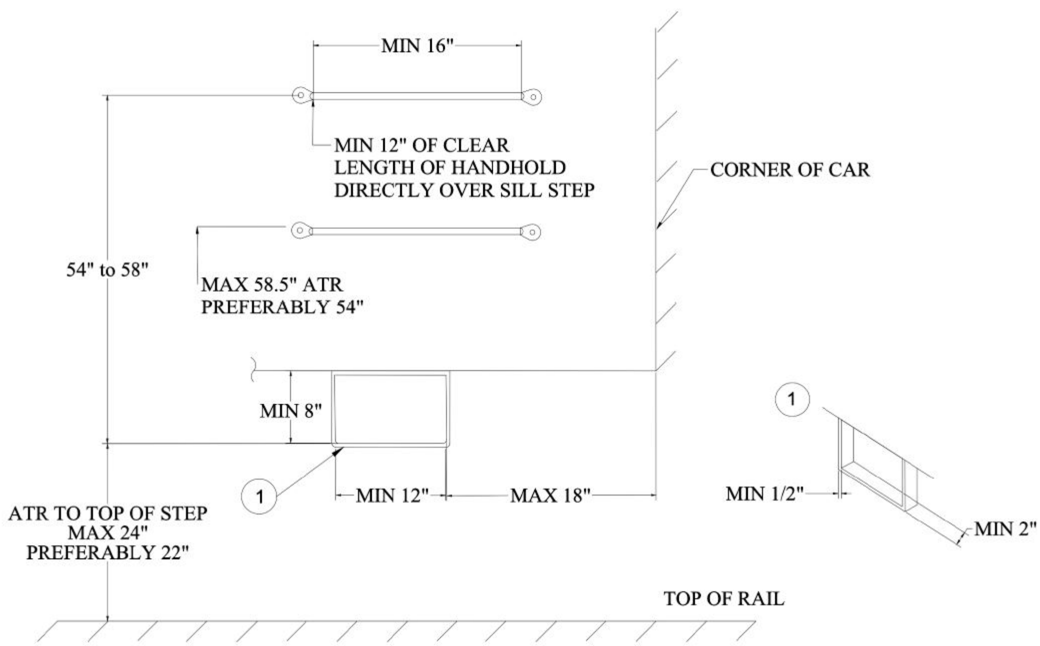
1. There shall be a minimum of two handholds over each sill step. If it is not possible to place two handholds over a sill step, then there shall be one handhold over that sill step, and it is recommended that the railroad prohibit employees from riding on that sill step.

NOTE: When only one sill step handhold is used, APTA recommends that a "DO NOT RIDE" sign be affixed to the car above the sill step.

If a passenger step is used in lieu of a sill step as noted in Section 3.2.2.2 (1), handholds shall be provided in accordance with Section 3.2.4.

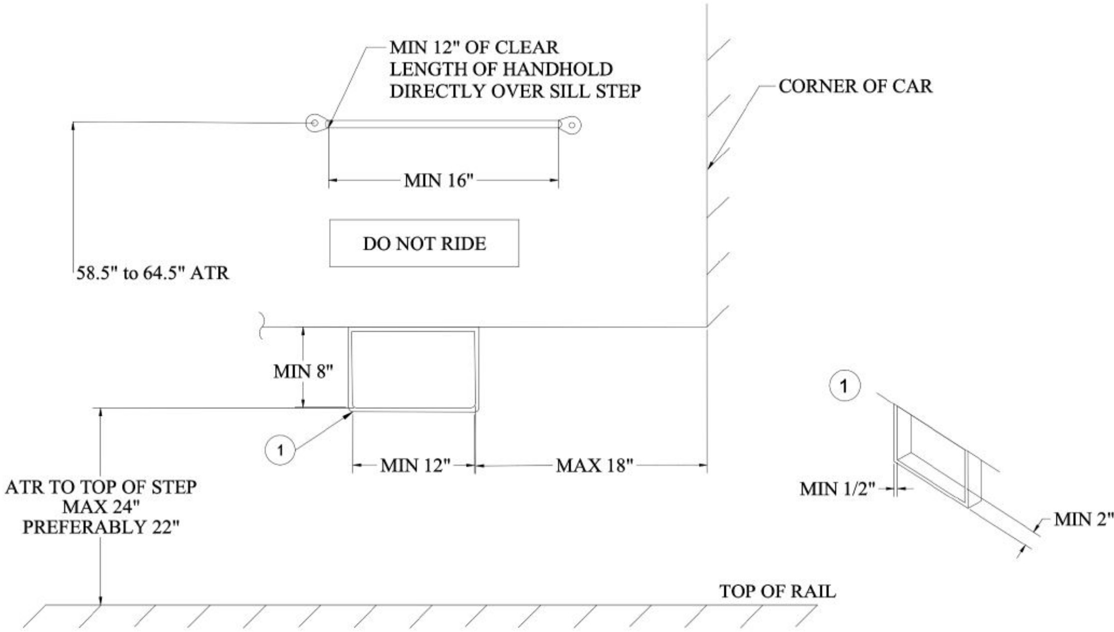
2. The lower handhold shall be at most 58½ in. (1485 mm), preferably 54 in. (1371 mm), above the top of rail (ATR). The second horizontal handhold shall be 54 to 58 in. (1372 to 1473 mm) above the lowest (riding) step. See **Figure 7**.

FIGURE 7
Sill Step with Two Horizontal Handholds



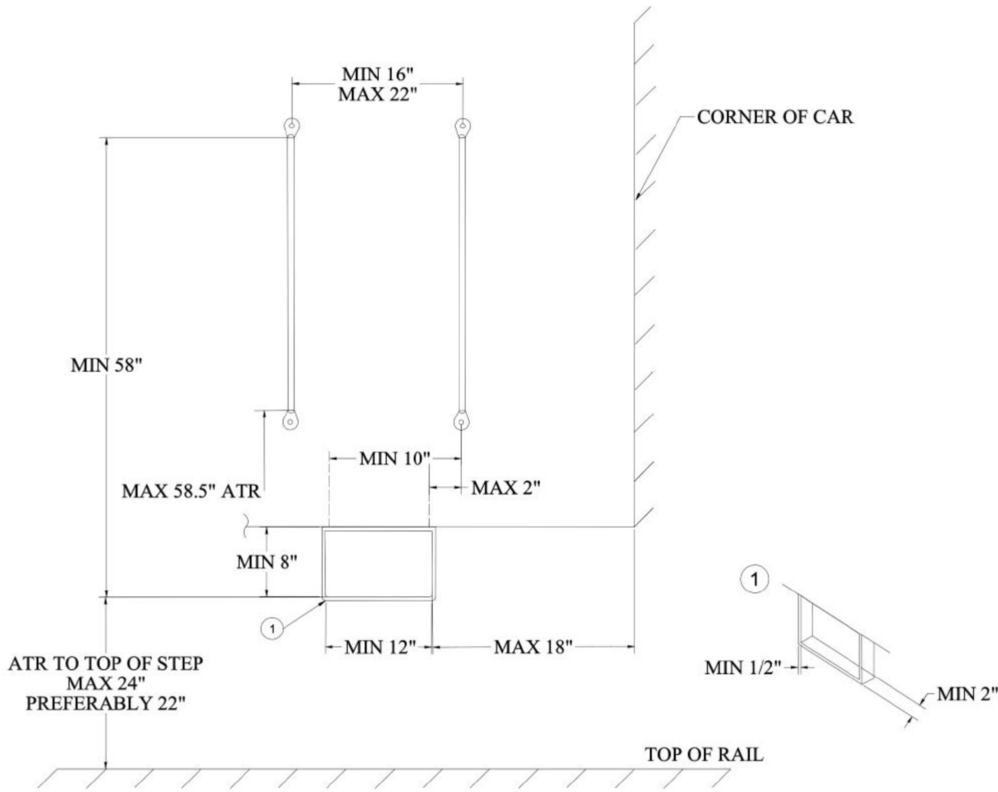
3. When one horizontal handhold is used, it shall be 58½ to 64½ in. (1486 to 1638 mm) ATR. See **Figure 8**.
4. 12 in. (305 mm) of the clear length of each horizontal handhold shall be directly over the sill step. See **Figure 7**.

FIGURE 8
Sill Step with One Horizontal Handhold



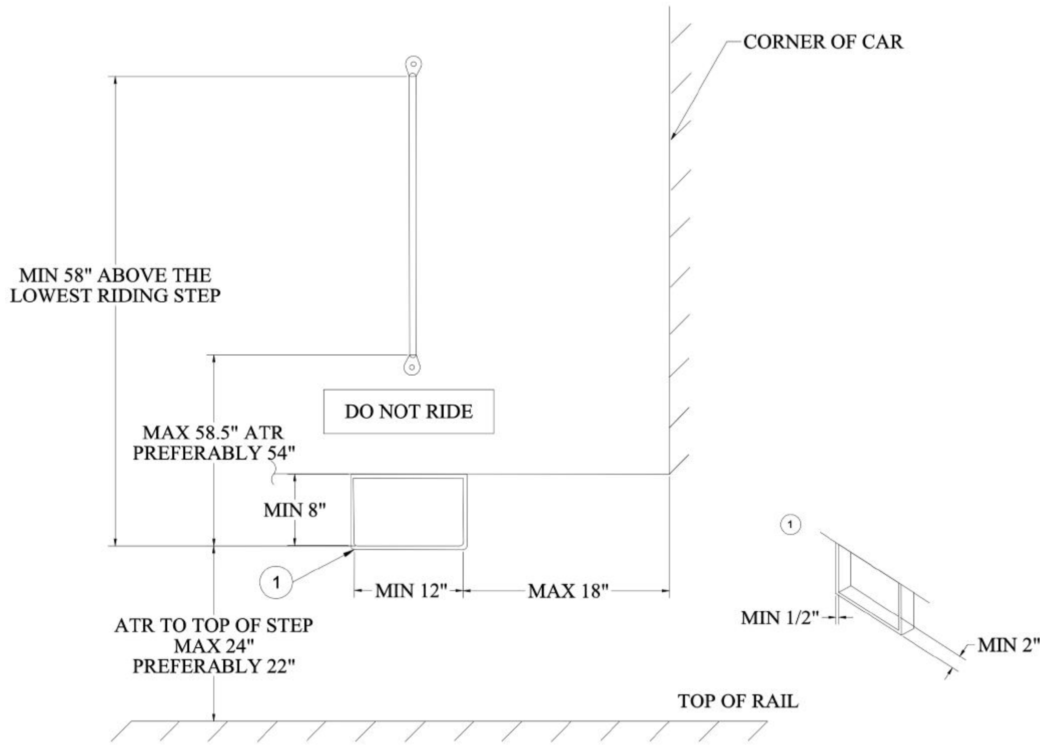
5. When at least two vertical handholds are used, the lowest clearance point of each vertical handhold shall be at most 58½ in. (1485 mm) ATR. The highest clearance point of each vertical handhold shall be at least 58 in. (1474 mm) above the lowest (riding) step. Each set of vertical handholds shall be spaced not less than 16 in. (407 mm) nor more than 22 in. (558 mm) apart. See **Figure 9**.

FIGURE 9
Sill Step with Two Vertical Handholds



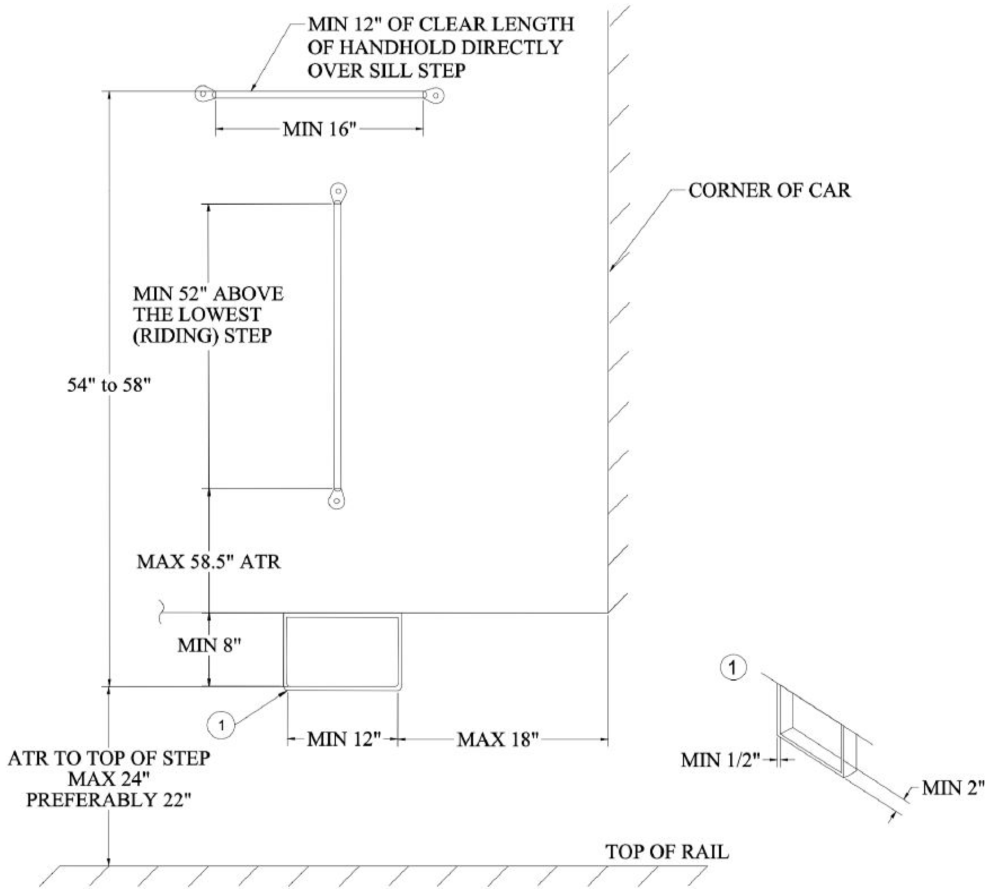
6. When one vertical handhold is used, its lowest clearance point shall be at most 58½ in. (1485 mm) ATR, preferably 54 in. (1371 mm) ATR. Its highest clearance point shall be at least 58 in. (1474 mm) above the lowest (riding) step. See **Figure 10**. The handhold shall be located above the clear length of the step.

FIGURE 10
Sill Step with One Vertical Handhold



7. To align two vertical handholds with the sill steps, the handholds shall be located in the longitudinal direction such that the inside face of the outboard handhold is no more than 2 in. (50 mm) outboard of the inside face of the outboard vertical leg of the step and is no less than 10 in. (254 mm) outboard from the inside face of the inboard vertical leg. See **Figure 9**.
8. When a combination of horizontal and vertical handholds is used, the horizontal handhold shall be 54 to 58 in. (1372 to 1473 mm) above the lowest (riding) step. The lowest clearance point of the vertical handhold shall be at most 58½ in. (1485 mm) ATR. The highest clearance point of the vertical handhold shall be at least 52 in. (1321 mm) above the lowest (riding) step. See **Figure 11**. One continuous handhold may be used as long as it meets the dimensional requirements of this paragraph. If possible, the vertical handhold should be within the clear length of the step.

FIGURE 11
Sill Step with One Horizontal and One Vertical Handhold



3.2.4 Handholds for riding at passenger steps

3.2.4.1 General

Low-level passenger boarding steps with a height of not more than 24 in. (609 mm) can be used in lieu of sill steps (where the functionality of sill steps is required in accordance with Section 3.2.2.2). In order to do so, the handhold provisions of this section shall apply.

3.2.4.2 Purpose/function

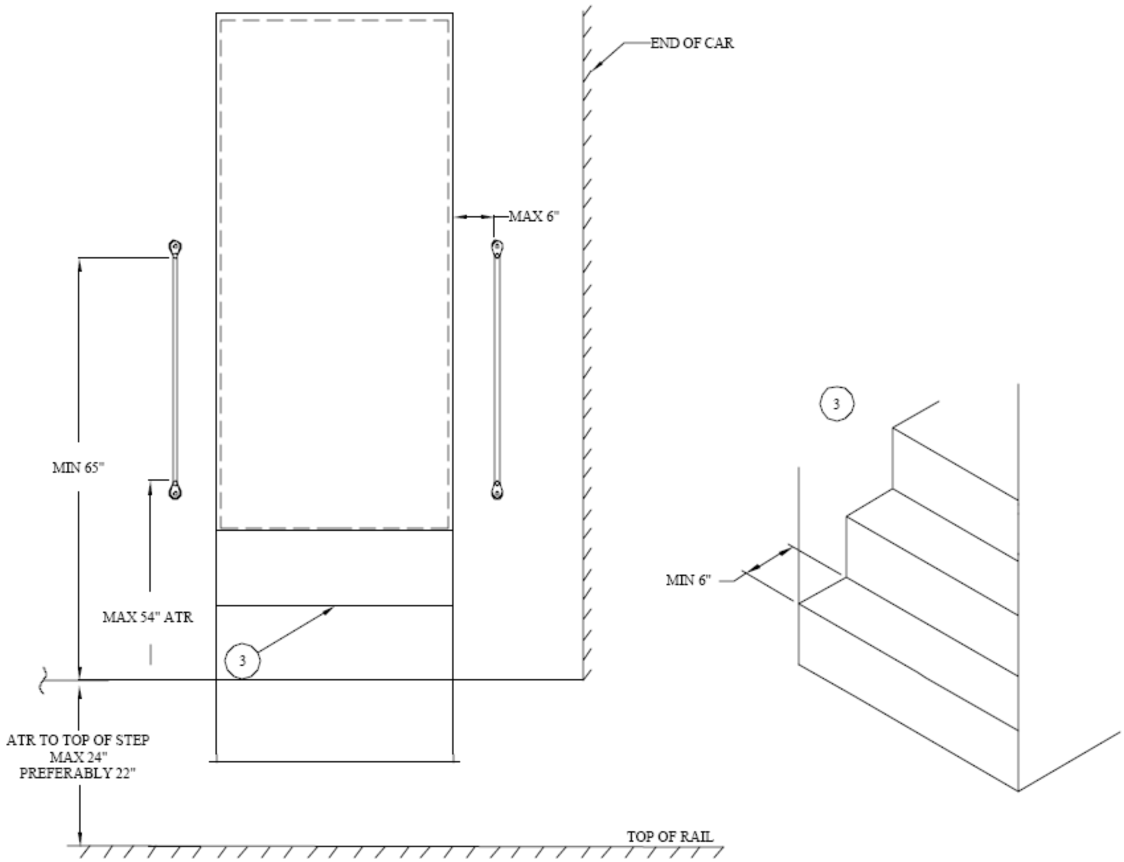
These handholds are used to assist an employee while riding the train for switching operations where passenger steps are used in lieu of sill steps.

3.2.4.3 Location

- There shall be two vertical handholds, one on each side of the door opening.
- The lowest clearance point of each crew handhold shall be at the most 54 in. (1371 mm) ATR.
- If the crew handhold is located outside the door opening, the crew handhold shall be located no more than 6 in. (152 mm) from the vertical inside face of the door opening.

See **Figure 12**.

FIGURE 12
Sill Step Handholds for Riding at Passenger Steps



3.3 Crew access

3.3.1 General requirements

1. The equipment shall provide locations where crew members can board or disembark the equipment safely from ground level (referenced at ATR) and be able to access all passenger and crew areas within every vehicle in the consist and be positioned to paragraphs (1)(a) or (b), depending on the type of equipment:
    a. A minimum of one crew access location per side per car.
    b. A minimum of two crew access locations per side per set of semi-permanently coupled passenger cars, provided that each location provides access to all the passenger and crew areas in the set.
2. The following access locations are considered acceptable crew access locations if all design requirements for crew access locations stipulated in this standard are met at those locations:
    a. Ground access from the side of the vehicle into cabs or machinery compartments (if equipped) if the whole interior of the vehicle can be reached by crew members from these areas.
    b. Passenger step access may be used for this purpose if all crew and passenger areas can be accessed by the crew members.
    c. Crew access steps and handholds shall be provided on any carbody side door directly leading into a cab or machinery compartment.
    d. Alternatively, retractable steps may be used as crew access steps as long as they meet the dimensional and location requirements for crew access steps.

e. Tier III trainsets may use portable ladders equipped with handrails designed for safe access from ground level in lieu of the requirements in this standard for crew access steps and handholds.

NOTE: If using this approach for Tier III equipment, FRA/TC will likely request the opportunity to review and approve the portable ladder arrangement.

3.3.1.1 Dimensions for crew access steps

1. The minimum usable length of tread shall be no less than 10 in. (254 mm), preferably 12 in. (305 mm).
2. Treads shall be no less than 2 in. (51 mm) wide.
3. Steps shall not have a vertical rise between treads exceeding 18 in. (457 mm). If needed to comply, additional treads shall be provided.
4. The clear depth above the entire usable length of the lowest crew access step tread shall be no less than 8 in. (204 mm), and the clear depth above the entire usable length of all other crew access step treads shall be no less than 6 in. (153 mm). For Tier III vehicles, both values may be reduced to 4.7 in. (120 mm). The clear width of all crew access step treads shall be no less than 6 in. (153 mm) with the trucks rotated to simulate the maximum curvature specified for the uncoupled car.
5. The portion of the tread surface area of each crew access step that is normally contacted by the foot shall be treated with an anti-skid material or be slip-resistant by texturing of the metal surface in such a way that it lasts the life of the car. Some examples of acceptable methods are diamond plate and stamped, upset or expanded metal. For enclosed step designs, at least 50% of the tread area shall be open space. For steps above the lowest step, the open space shall extend at least 1 in. (26 mm) below the top surface of the tread.
6. To account for minor deviations, the application of crew access steps shall be such that a box with the dimensions shown in **Table 3** can pass through the opening above the crew access step to the point where the box is flush with the outer edge of the step.

TABLE 3
Side Door Step Dimensions

	Box Length	Box Depth	Box Width
Lowest side door step	10 in. (254 mm)*	8 in. (204 mm)	6 in. (153 mm)
All side door steps, except lowest	10 in. (254 mm)*	6 in. (153 mm)	6 in. (153 mm)
All side door steps (Tier III)	10 in. (254 mm)*	4.7 in. (120 mm)	6 in. (153 mm)

* Box Length Preferably 12 inches (305 mm)

3.3.1.2 Dimensions for crew access handrails

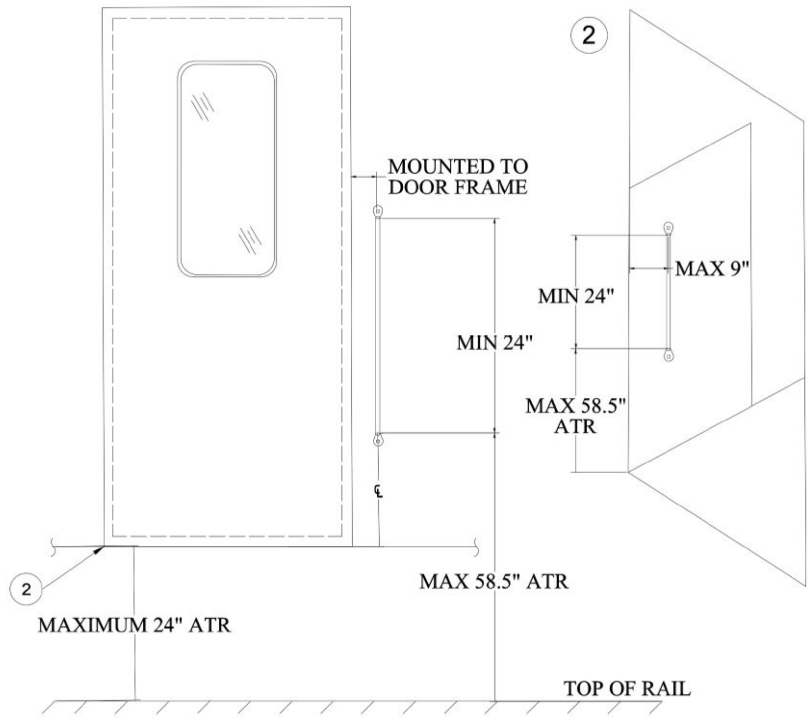
Handrails shall be no less than ⅝ in. (16 mm) in diameter. Minimum clear length of vertical handrails shall be 24 in. (610 mm). Minimum clearance shall be 2 in. (51 mm), preferably 2½ in. (64 mm).

Where interior handrails are used for passenger access, the handrail diameter and the minimum clearance around the vertical handrail shall comply with §38.97(a) or §38.115(a).

3.3.2 Requirements for crew access at low-level floors

Low-level floor equipment includes those cars having the door thresholds at a height no more than 24 in. (609 mm) above the top of rail.

FIGURE 13
Crew Access at Low-Level Floors



3.3.2.1 Steps

Additional crew access steps are not needed where the door threshold is at a height not more than 24 in. (609 mm), preferably 22 in. (558 mm) ATR.

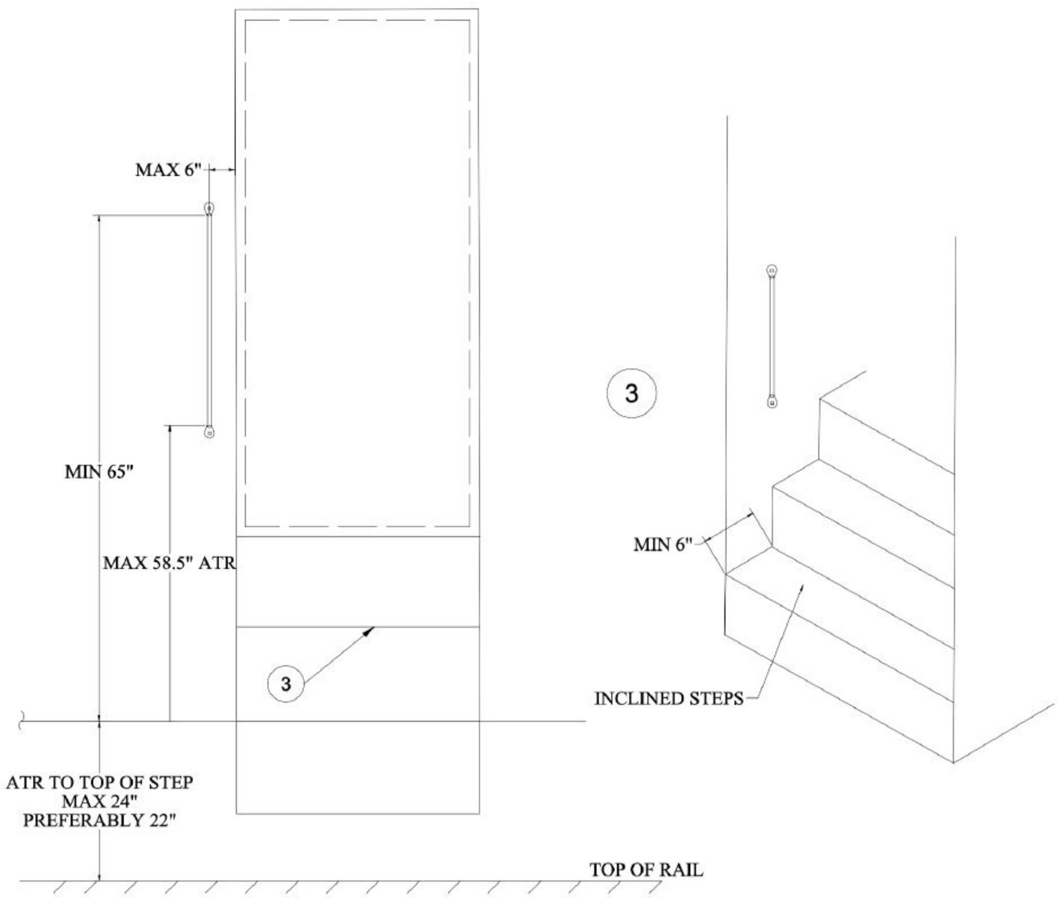
3.3.2.2 Handholds

1. There shall be at least one vertical handhold on one side of the door opening, inside of the car or on the doorframe, not more than 9 in. (228 mm) from the outside face of the door opening.
2. The lowest clearance point of the vertical handrail shall be at most 58½ in. (1485 mm) ATR.

3.3.3 Requirements for crew access at high-level floors with inclined steps

A high-level floor is defined in this section as an interior car floor with a height greater than 24 in. (610 mm) ATR.

FIGURE 14
Crew Access at High-Level Floors with Inclined Steps



3.3.3.1 Steps

1. The first (lowest) crew access step shall be not more than 24 in. (609 mm), preferably not more than 22 in. (558 mm) ATR.
2. For designs that have inclined steps with the lowest step more than 24 in. (609 mm), additional crew access steps and handholds shall be applied in accordance with Section 3.3.4.

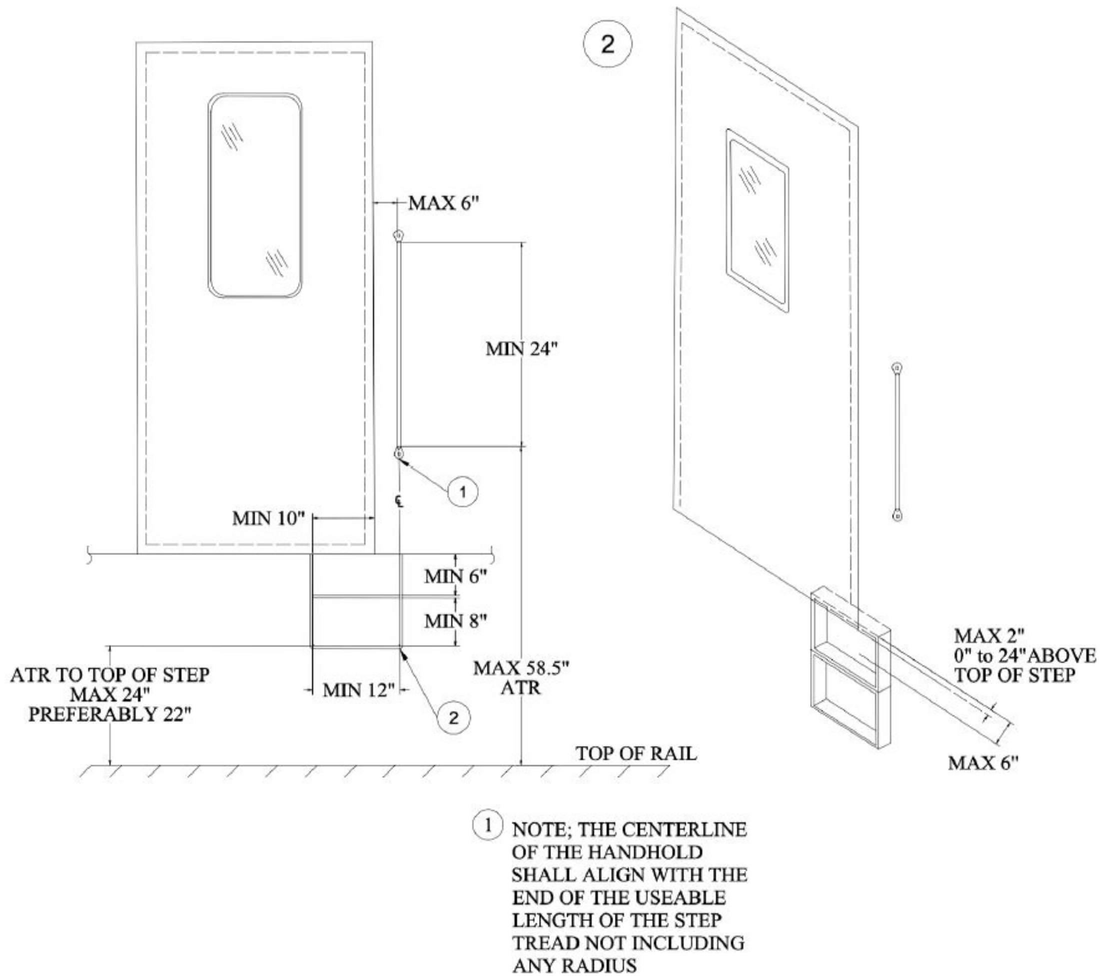
3.3.3.2 Handholds

1. There shall be at least one vertical crew handhold on the side of the door opening.
2. The lowest clearance point of the vertical handrail shall be at most 58½ in. (1485 mm) ATR.
3. There shall be a second handhold provided to facilitate stepping up into the car.
4. If the crew handhold is located outside the door opening, the crew handhold shall be located no more than 6 in. (152 mm) from the vertical inside face of the door opening.

3.3.4 Requirements for crew access at high-level floors with vertical steps or ladders

A high-level floor is defined in this section as an interior floor with a height greater than 24 in. (610 mm) ATR without inclined steps. See **Figure 15**.

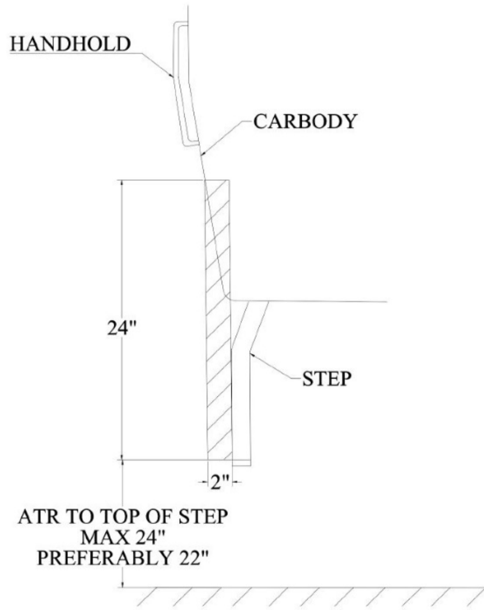
FIGURE 15
Crew Access at High-Level Floors with Vertical Steps



3.3.4.1 Steps

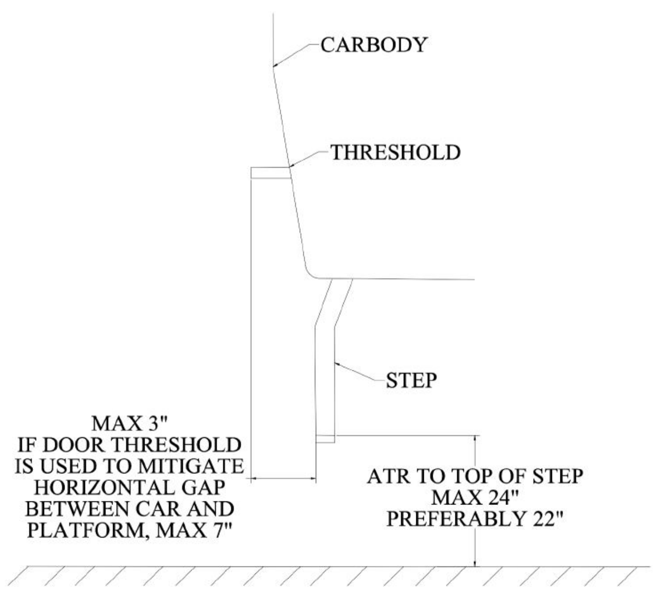
1. The treads shall be aligned with the door opening to provide at least 10 in. (254 mm) of tread within the clear door opening. The opposing ends of the treads shall align with or extend past the centerline of the crew access handhold.
2. The lowest tread shall be not more than 24 in. (609 mm), preferably not more than 22 in. (558 mm) ATR. The design goal is to have the lowest tread as close to the top of rail as permitted by the clearance diagram.
3. The outside edge of any tread shall be no more than 2 in. (50 mm) inboard of any car structure or treads within 24 in. (609 mm) directly above the clear length of any step. A maximum of 4 in. (101 mm) is permitted for treads at or below 21 in. (534 mm) ATR, provided it is otherwise not possible to remain within the clearance diagram. The design goal is to have the outside edge of the crew access step tread to be as flush with the side of the car as the clearance diagram permits. See **Figure 16**.

FIGURE 16
Carbody Structure Clearance with Step Tread



4. The outside edge of any tread shall be no more than 3 in. (76 mm) inboard of the door threshold. If the door threshold is used to mitigate the horizontal gap between the car and platform, up to 7 in. (177 mm) is permitted. See **Figure 17**.

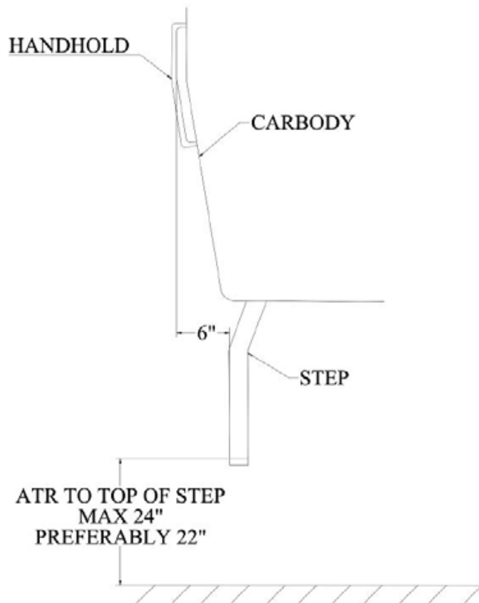
FIGURE 17
Allowable Transverse Alignment for Step and Threshold



5. The outside edge of all treads shall be aligned in the transverse direction within 6 in. (152 mm) inboard to 8 in. (203 mm) outboard of the exterior sidewall plane at the handhold attachment points inside surface of the adjacent handhold at any point along the handhold clear length. The design goal

is to have the outside edge of the crew access step to be as aligned with the crew access handhold as the clearance diagram permits. See **Figure 18**.

FIGURE 18
Allowable Transverse Alignment for Step and Handhold



3.3.4.2 Handholds

1. There shall be one interior or exterior vertical crew access handhold over each crew access step located between the inside faces of the legs of the crew access step. If an exterior handhold is used, then an additional interior handhold shall be provided to facilitate stepping up into the car. This additional handhold does not need to meet the lowest clearance point in paragraph (2).
2. The lowest clearance point of the crew access handhold shall be at most 58½ in. (1485 mm), preferably 54 in. (1371 mm), ATR.
3. An exterior crew access handhold shall be located no more than 6 in. (152 mm) from the vertical inside face of the door opening.
4. When ground access is provided for cabs or machinery compartments, two vertical side door handrails shall be provided, one on each side of the door, to continue to a point at least 60 in. (1524 mm), or as high as practicable based on carbody design, above the floor of the cab at the door entrance. For Tier III equipment, the handholds shall continue to a point at least 48 in. (1220 mm), or as high as practicable based on carbody design, above the cab floor at the door entrance. If a 2 in. (51 mm) minimum clearance cannot be provided for the entire length due to handrails being secured at locations between the top and bottom connections, alternate configurations that are ergonomically designed for the intended function may be used as approved by the railroad.

NOTE: Any deviations may require FRA/TC approval.

3.4 End handholds

3.4.1 General

Two end handholds are required at each end of a vehicle or trainset unit equipped with an automatic coupler. However, end handholds are not required at ends of vehicles or trainset units equipped with an automatic coupling mechanism that can be safely operated from inside the appropriate cab of the vehicle and does not require ground intervention from a person such as to go on, under or between to couple air, electric or other connections.

3.4.2 Purpose/function

End handholds are used to stabilize an employee when performing such tasks as making or breaking end connections, opening and closing angle cocks and performing inspections.

3.4.3 Dimensions

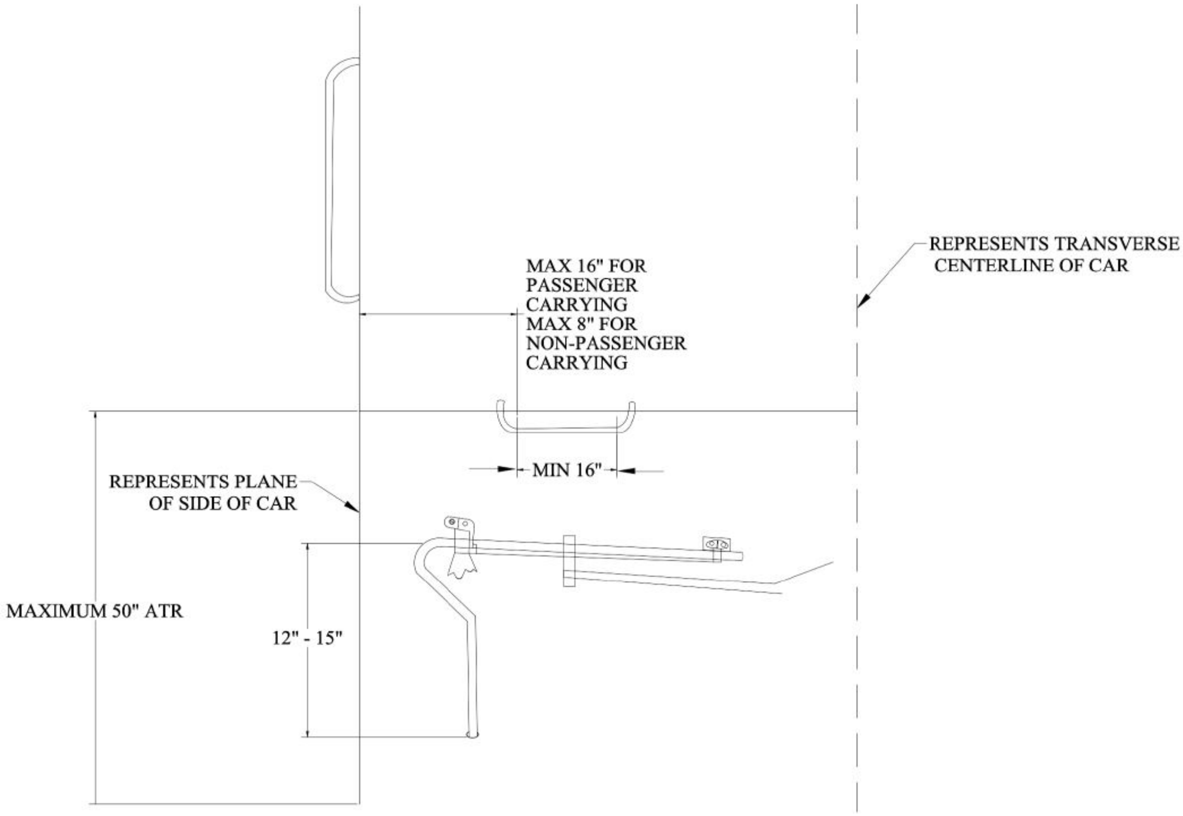
Handholds shall be no less than ⅝ in. (16 mm) in diameter. Minimum clear length of end handholds shall be 16 in. (407 mm). Minimum clearance shall be 2 in. (51 mm), preferably 2½ in. (64 mm), with end connections applied and end receptacle covers in resting position.

3.4.4 Location

1. End handholds shall be oriented horizontally, one near each side on each end projecting from the face of the end sill or sheathing.
    a. For passenger-carrying vehicles, the clearance point of the outboard end of the end handhold shall be not more than 16 in. (406 mm) from side of car.
    b. For non-passenger-carrying locomotives, the clearance point of the outboard end of the end handhold shall be not more than 8 in. (203 mm) from side of car.
2. If the equipment is designed with a tapered nose, the side of the car shall be determined based on the outer dimension of the tapered nose where the end handhold is attached.
3. The handholds shall be located not greater than 50 in. (1270 mm) from top of rail. Handholds may be attached to any primary structure (e.g., carbody frame or pilot, or plow on cab cars), so long as it meets the dimensions above.
4. An uncoupling lever may be used as an end handhold if it otherwise meets the requirements for end handholds.

See **Figure 19**.

FIGURE 19
End Handhold and Uncoupling Lever



3.5 Collision post handholds

3.5.1 General

Two collision post handholds shall be at each end passageway if that passageway is utilized for guiding reverse moves.

3.5.2 Purpose/function

Collision post handholds provide a means to stabilize an employee standing at the end of the car guiding reverse moves. Collision post handholds also provide a means to stabilize an employee when walking between cars.

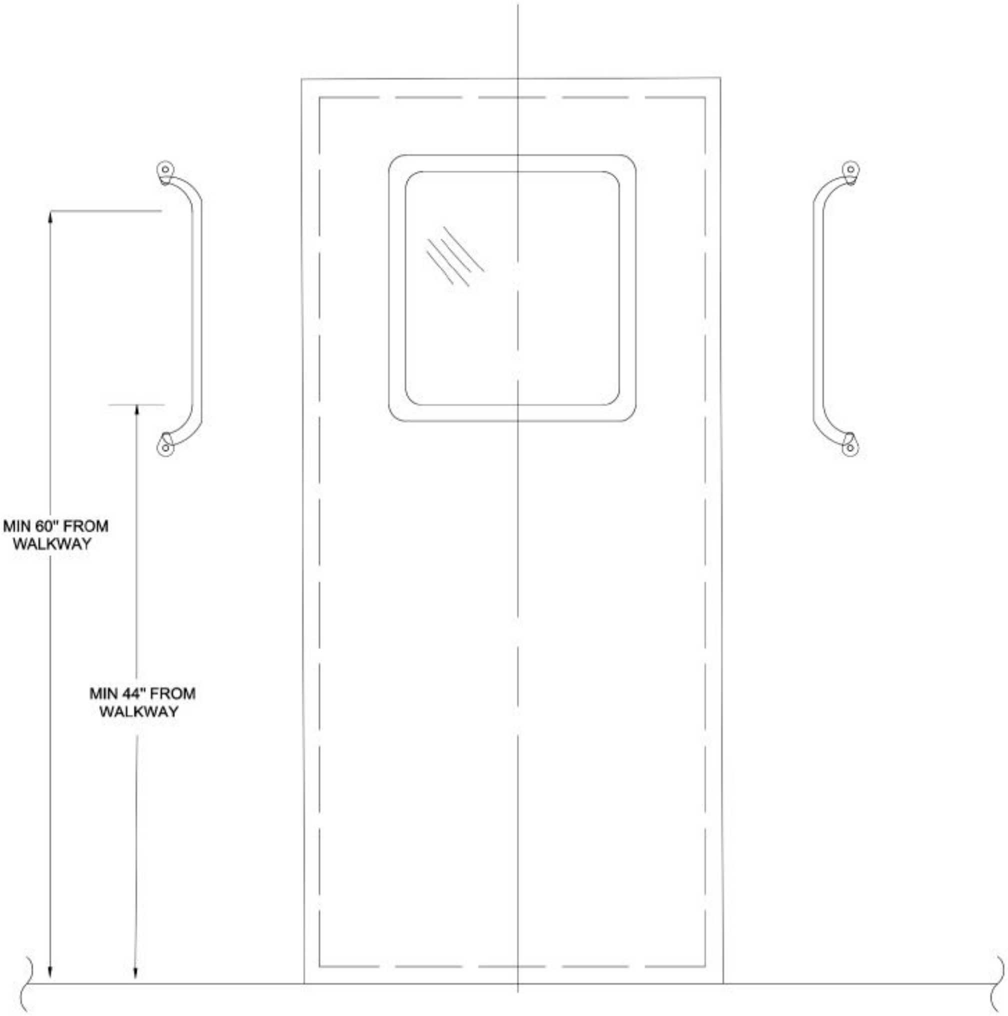
3.5.3 Dimensions

Handholds shall be no less than ⅝ in. (16 mm) in diameter. Minimum clearance shall be 2 in. (51 mm), preferably 2½ in. (64 mm).

3.5.4 Location

Collision post handholds shall be oriented vertically. The lowest clearance point shall be at most 44 in. (1117 mm) above the floor of the walkway, and the highest clearance point shall be at least 60 in. (1524 mm) above the floor of the walkway. See **Figure 20**.

FIGURE 20
Collision Post Handholds



3.6 Handrail on open platform cars

3.6.1 General

Open platform cars shall have the platform area enclosed. If handrails are used to enclose the platform area and are intended to stabilize an employee standing in this area, the requirements of this section shall apply.

3.6.2 Purpose/function

A handrail or a shortened wall is used on open platform cars to enclose the platform area and stabilize an employee standing on the open platform.

3.6.3 Dimensions

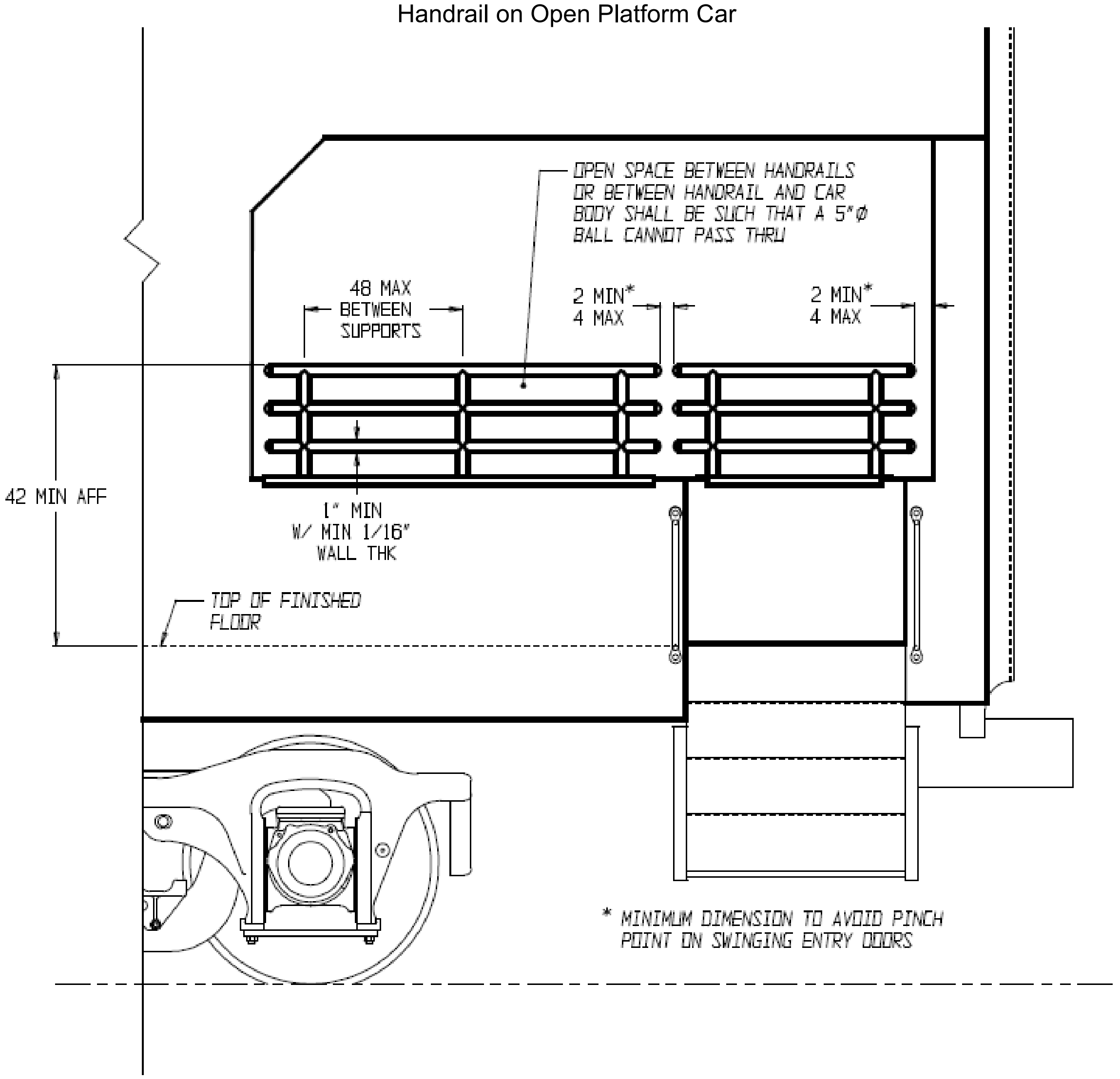
Handrails shall be no less than ⅝ in. (16 mm) diameter steel. Alternatively, handrails shall be no less than 1 in. (26 mm) diameter tubing with a minimum wall thickness of $\frac{1}{16}$ in. (2 mm).

3.6.4 Location

1. Open platform cars shall have the platform area enclosed with either a handrail or shortened walls. The handrail may be continuous or may be intermittent to extend between other members of the car, such as collision posts and corner posts.
2. If an intermittent handrail is used, the end of the handrail shall be capped with a rounded end to reduce risk of injury.
3. The distance from the end of the handrail to a vertical car member shall not exceed 4 in. (101 mm).
4. The handrail shall be at least 42 in. (1067 mm) from the top of the platform floor to the top of the handrail, including entry doors.
5. The handrail arrangement shall be designed such that a 5 in. (127 mm) diameter ball cannot pass through any space between handrail members or between the handrail and the carbody.
6. Handrail members shall not be unsupported for spans over 48 in. (1219 mm).
7. The railing and stile assembly may be welded but the ends of the final assembly must be securely fastened to the car structure.
8. If a shortened wall is used, it shall meet the location requirement for handrails as detailed in paragraphs (1) through (7) above.

See **Figure 21**.

FIGURE 21
Handrail on Open Platform Car



3.7 Uncoupling devices

3.7.1 General

Each passenger-carrying vehicle end equipped with an automatic coupler shall have either:

- a manual uncoupling lever; or
- an uncoupling mechanism operated by remote controls.

Each non-passenger-carrying locomotive end equipped with an automatic coupler shall have either:

- a manual double-lever uncoupling lever, operative from either side of the locomotive; or
- an uncoupling mechanism operated by remote controls.

Additional manual uncoupling levers or handles provided on the coupler as a backup for the remotely operating mechanism shall not be subject to the requirements of this standard.

3.7.2 Purpose/function

The uncoupling device is a mechanism used to uncouple cars without requiring an employee to go between cars.

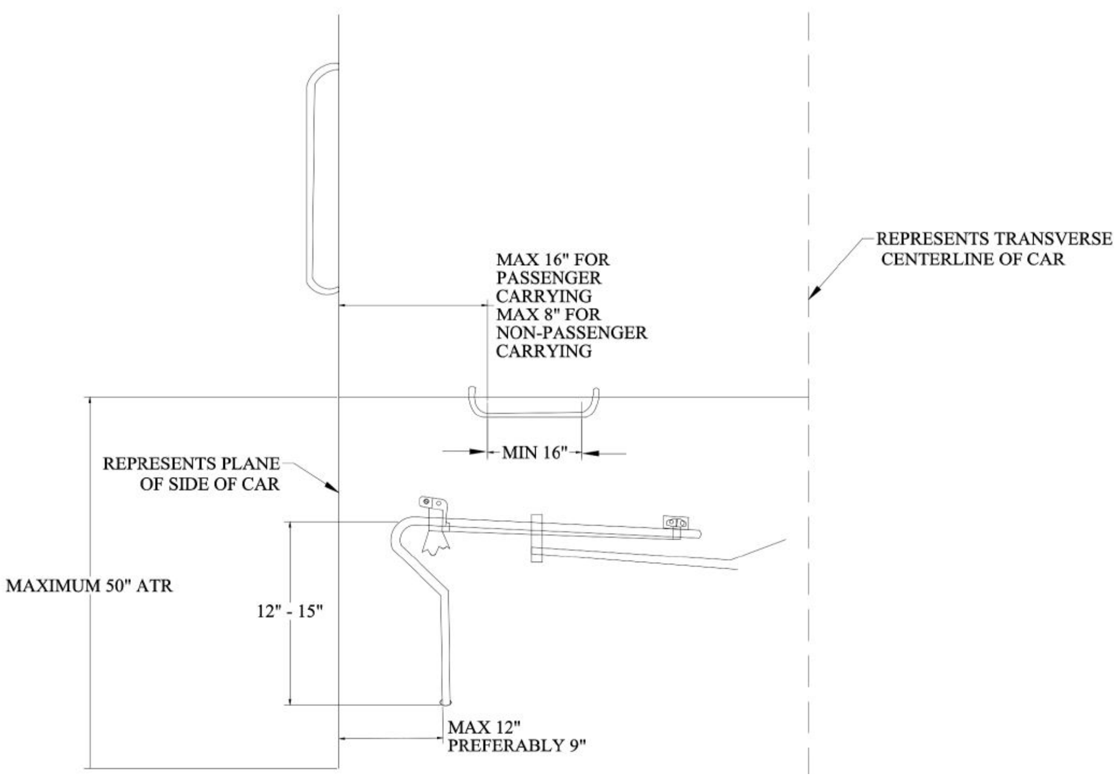
3.7.3 Dimensions

If a manual uncoupling lever is provided, the following shall apply:

1. Lever handles shall not be more than 12 in. (304 mm), preferably 9 in. (228 mm):
   a. from the side of the car; or
   b. for cab ends with shrouding or aerodynamic treatment, from the outer dimension of the tapered nose at the location where the end handhold is attached.
2. Uncoupling attachments shall be applied so they can be operated by a person standing on the ground.
3. The bottom end of the handle shall be no less than 12 in. (305 mm) and no more than 15 in. (381 mm) below the centerline of the outermost pivot point of the uncoupling lever to which the handle is attached.
4. The end of the handle shall be constructed to provide a minimum 2 in. (51 mm), preferably 2½ in. (64 mm) clearance around the handle.

See **Figure 22**.

FIGURE 22
End Handhold and Uncoupling Lever



3.7.4 Location

When used, the manual uncoupling levers shall be located in the following manner.

1. For passenger cars, the uncoupling lever shall be applied so the coupler can be operated from the left side of the car as seen when facing the end of the car from the ground.
2. For non-passenger locomotives, uncoupling levers shall be applied so the coupler can be operated from both sides of the locomotive.
3. Road locomotives with corner stairway openings must be equipped with uncoupling mechanisms that can be operated safely from the bottom stairway opening step, as well as ground level. No part of the uncoupling mechanism may extend into the stairway opening or end platform area when the mechanism is in its normal position or when it is operated.

When used, the uncoupling mechanism operated by remote controls shall be located in the appropriate cab or control stand. See **Figure 22**.

3.7.5 Manner of application

The uncoupling lever device shall be securely fastened to the carbody structure or supporting bracket.

3.8 Conditional safety appliances

Safety appliances in this section are considered mandatory if either the design of the car or railroad operating rules, and actual practice, entails the maintenance or replacement of equipment conducted by maintenance personnel in locations not protected by the requirements of Part 218, Subpart B. If not, these safety appliances can be omitted.

3.8.1 Handholds and steps for appurtenances and windshields

Vehicles having appurtenances such as headlights, windshield wipers, marker lights and other similar items required for the safe operation of the vehicle and designed to be replaced from the exterior of the vehicle shall have handholds and steps meeting the dimension and clearance requirements of side door steps and side door handholds to allow for the safe maintenance and replacement of these parts. Alternatively, the requirements for ladders or a combination of ladders, steps and handholds may be used.

3.8.2 Ladders

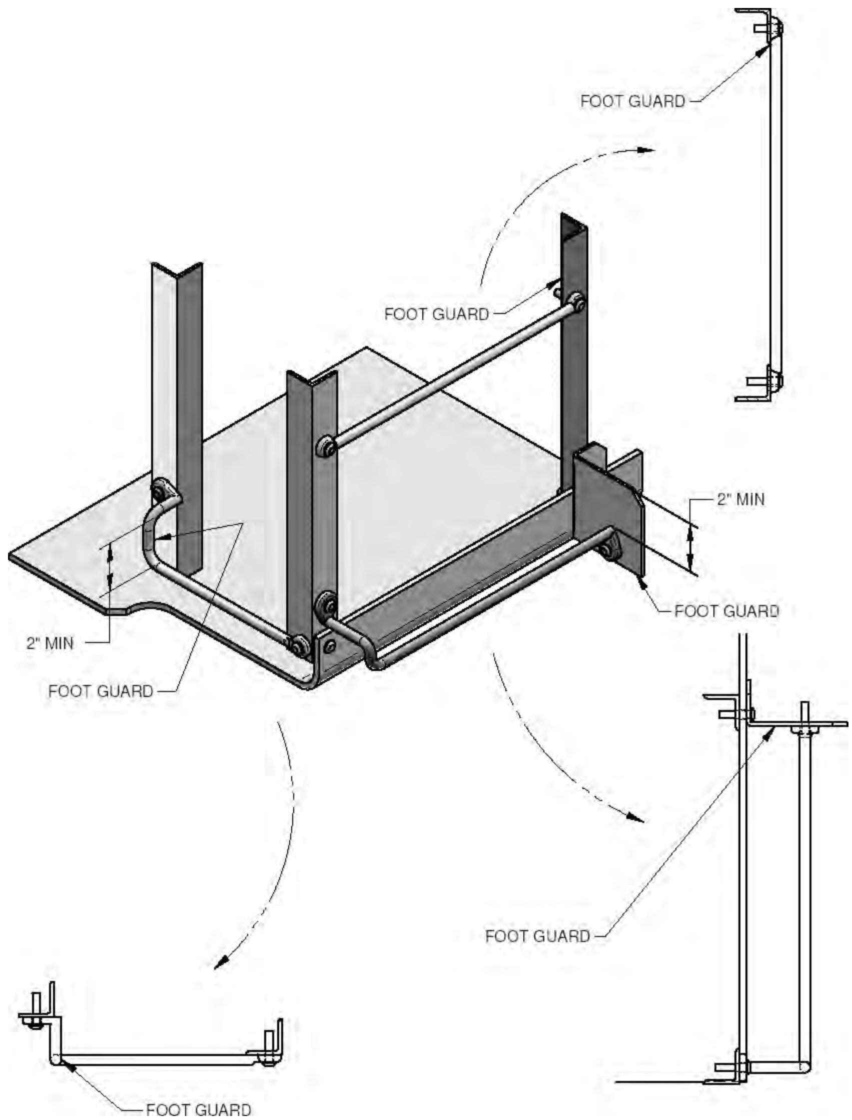
3.8.2.1 Purpose/function

Ladders enable an employee to access equipment or to perform a function that cannot be done from the ground.

3.8.2.2 Dimensions

1. The minimum usable length of tread shall be not less than 16 in. (407 mm) on side ladders and not less than 14 in. (356 mm) on end ladders.
2. Treads of rectangular cross-section shall be no less than 2 in. (51 mm) wide. The minimum diameter of treads of circular cross-section shall be ⅝ in. (16 mm) in diameter.
3. Minimum clearance of treads shall be 2 in. (51 mm), preferably 2½ in. (64 mm).
4. All ladder treads shall have foot guards. Ladder side rails may serve as foot guards (**Figure 23**).

FIGURE 23
Foot Guards on Ladder Treads



3.8.2.3 Location

1. If the ladder is used for access to the roof, the top ladder tread shall be no less than 12 in. (305 mm), and no more than 18 in. (457 mm), below the mounting surface of the outboard end of the adjacent roof handhold.
2. The maximum spacing between ladder treads shall be 19 in. (482 mm). Spacing of ladder treads shall be uniform within a limit of 2 in. (50 mm) from top tread to bottom tread of ladder.

3.8.3 General appliances for moving on side and end walls

3.8.3.1 Purpose/function

These safety appliances are used for accessing the vehicle or moving on its walls where standard arrangements do not fit.

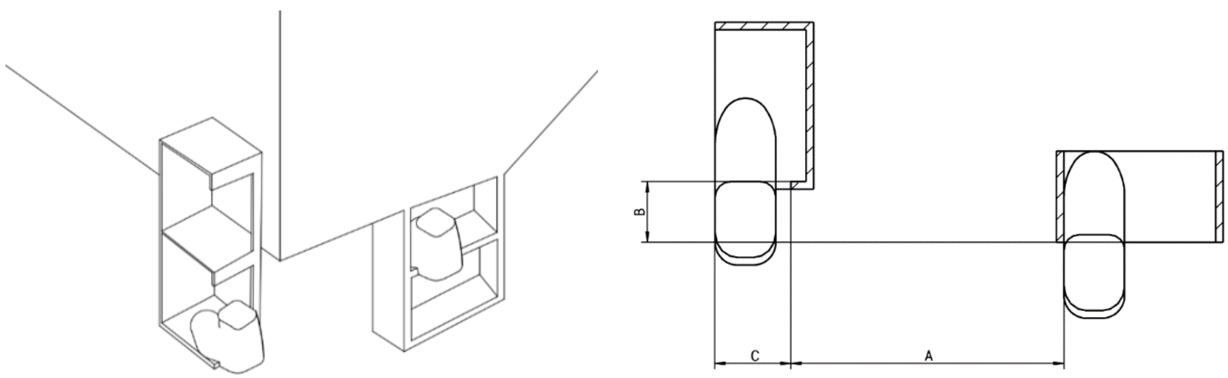
3.8.4 Dimensions

All handholds and steps shall meet the dimension and clearance requirements of side door steps and side door handholds. Alternatively, the requirements for ladders or a combination of ladders, steps and handholds may be used.

3.8.4.1 Stepping around the corner of a vehicle

1. Treads for stepping around the corner of a vehicle shall be aligned vertically; a maximum vertical variation of 2 in. (50 mm) is allowed.
2. The total horizontal distance between the steps around the corner shall not be more than 16 in. (406 mm) (a+b dimension; see **Figure 24**), measured from the inside edge of ladder foot guards or the clearance of treads.
3. If the design allows for both feet to be parallel during the transition, a maximum of 22 in. (558 mm) (a+b dimension in **Figure 24**) of total horizontal distance around the corner shall be allowed for transitioning from one ladder to the other. The clear length for placing the feet shall be a minimum 5 in. (127 mm) (c dimension in **Figure 24**) and fully supported on the tread surface.

FIGURE 24
Stepping Around the Corner of a Vehicle



3.8.5 Roof handholds

3.8.5.1 Purpose/function

Roof handholds are used on the roof of the car to stabilize an employee when performing such tasks as inspecting equipment located on the roof.

3.8.5.2 Dimensions

Handholds shall be no less than ⅝ in. (16 mm) in diameter. Minimum clear length shall be 16 in. (407 mm). Minimum clearance shall be 2 in. (51 mm), preferably 2½ in. (64 mm).

3.8.5.3 Location

If roof handholds are located above a ladder, then the centerline of the roof handhold shall be no more than 8 in. (203 mm) from the centerline of the ladder in the transverse direction.

3.9 Optional (elective) steps and handholds

Steps and handholds applied to the exterior of cars in addition to those required by this standard are defined as optional (elective) steps and handholds and shall comply with the requirements of this standard that are applicable to similar safety appliances, except for their quantity and location, to the extent practicable.

4. Safety appliance design verification inspection

The railroad and the carbuilder may use the checklist in Appendix A as a tool in verifying that all the requirements of this standard have been addressed.

The carbuilder or railroad shall request a safety appliance sample car inspection from the FRA in the United States or Transport Canada in Canada on each new design of car. If any design changes take place to safety appliances during production, the railroad shall request an additional safety appliance sample car inspection.

Previous sample car inspections can be applied to new orders of the same design if there are no changes to the safety appliances. However, FRA and TC will require submittal of the safety appliance arrangement drawings for that order with reference to the previous sample car inspection.

This inspection can be combined with the standard sample car inspection. Both FRA and TC require inspection of items in addition to safety appliances during the sample car inspection.

Contact FRA and/or TC for details on these requirements.

It is recommended that a safety appliance design review with the Federal Railroad Administration or Transport Canada be conducted as early as possible in the design process. The carbuilder or railroad shall submit a written request to FRA and/or TC at least 30 days prior to a sample car inspection. The letter shall include the drawings of all safety appliances and may include the completed checklist in Appendix A. The letter shall be sent to:

Federal Railroad Administration:
Director, Office of Safety Assurance and Compliance
|Federal Railroad Administration
US Department of Transportation
1200 New Jersey Ave. S.E.
Washington, DC 20590

Transport Canada:
Transport Canada Rail
Safety Enterprise Building
427 Laurier Ave. W.
14th floor, Suite 1410
Ottawa, Ontario Canada, K1A 0N5

5. Inspection, maintenance, repair and replacement

5.1 Inspection

Safety appliances shall be inspected in accordance with the respective sections of 49 CFR 238; and/or Transport Canada’s Railway Passenger Car Inspection and Safety Rules as applicable.

5.2 Maintenance

Safety appliances shall be maintained in accordance with the respective sections of 49 CFR 238; and/or Transport Canada’s Railway Passenger Car Inspection and Safety Rules as applicable.

5.3 Repair and replacement

Safety appliances shall be repaired and replaced in accordance with the respective sections of 49 CFR 238; and/or Transport Canada’s Railway Passenger Car Inspection and Safety Rules as applicable.

Fastener locking devices shall not be reused.

Related APTA standards

APTA PR-CS-S-020-03, Latest Revision "Passenger Rail Vehicle Structural Repair"
APTA PR-IM-S-007-98,Latest Revision, "Passenger Car Exterior Periodic Inspection and Maintenance"
APTA PR-M-S-006-98, Latest Revision, "Parking Brakes for New Passenger Locomotives and Cars"

References

This standard is to be used in conjunction with the following publications. When non-regulatory references are superseded by an approved revision, the revision shall apply for this standard and APTA will petition the Federal Railroad Administration and Transport Canada for a corresponding change in their rules and regulations.

Code of Federal Regulations:
- 49 CFR, Part 231, Railroad Safety Appliance Standards
- 49 CFR, Part 238, Rail Passenger Equipment Safety Standards AAR S-2044, Requirements for Freight Car Safety Appliances

American Welding Society standards:
- AWS D1.1-06, Structural Welding Code – Steel
- AWS D1.3-98, Structural Welding Code – Sheet Steel
- AWS D1.6-99, Structural Welding Code – Stainless Steel

Canadian Standards Association standards:
- CSA W47.1-03, Certification of Companies for Fusion Welding of Steel
- CSA W59-03, Welded Steel Construction (Metal Arc Welding)

Transport Canada's Passenger Car Inspection and Safety Rules

Bibliography

AAR Manual of Standards and Recommended Practices:
- Section B, S-132, Type No. 6 Operating Mechanism
- Section C, S-224, Handhold and Ladder Tread Material and Design Specifications
- Section C, S-2042, Sill Step Performance Specification
- Section E, S-475, Geared Hand Brakes

"FRA Motive Power and Equipment Compliance Manual," Chapter 2, Inspection and Compliance Program

SAE J429, 1999, "Mechanical and Material Requirements for Externally Threaded Fasteners"

EN 16116, Railway applications. Design requirements for steps, handrails and associated access for staff. Passenger vehicles, luggage vans and locomotives

SAE J185, "Access Systems for Off-Road Machines"

Definitions

All CFR definitions cited here are current as of the date of publication of this standard and provided here for convenience only. However, the user should refer to the latest definitions in the CFR.

automatic coupler: A coupler that allows for mechanical coupling upon impact and uncoupling by either activation of a traditional uncoupling lever, or some other type of uncoupling mechanism that does not require a person to go on, under or between the equipment units.

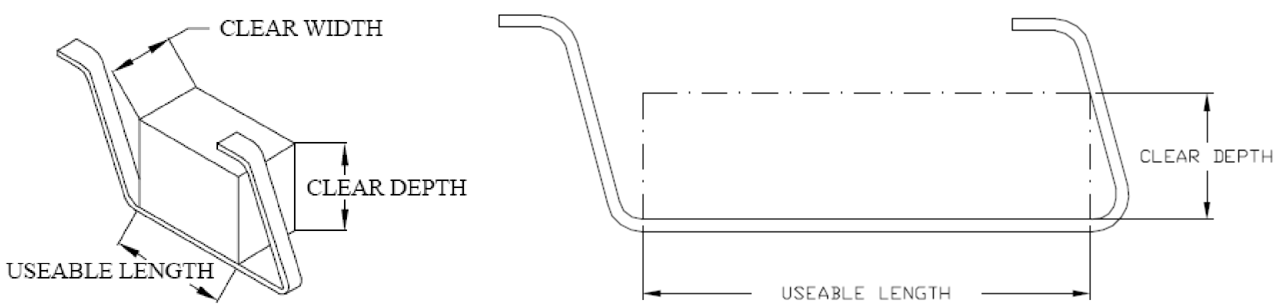
automatic coupler, fully: A coupler that allows for all required mechanical, electrical, and pneumatic coupling upon impact and mechanical, electrical and pneumatic uncoupling by activation of a control within the vehicle.

cab: A locomotive cab defined per 49 CFR §238.5, and for the purposes of this APTA standard, the cab shall also include a space onboard a locomotive where an auxiliary control stand (or hostler stand) is located that is normally occupied by the engineer (or hostler engineer) when the locomotive is operated for switching moves in a yard or maintenance facility.

cab, locomotive (49 CFR §238.5 definition): The compartment or space onboard a locomotive where the control stand is located, and which is normally occupied by the engineer when the locomotive is operated.

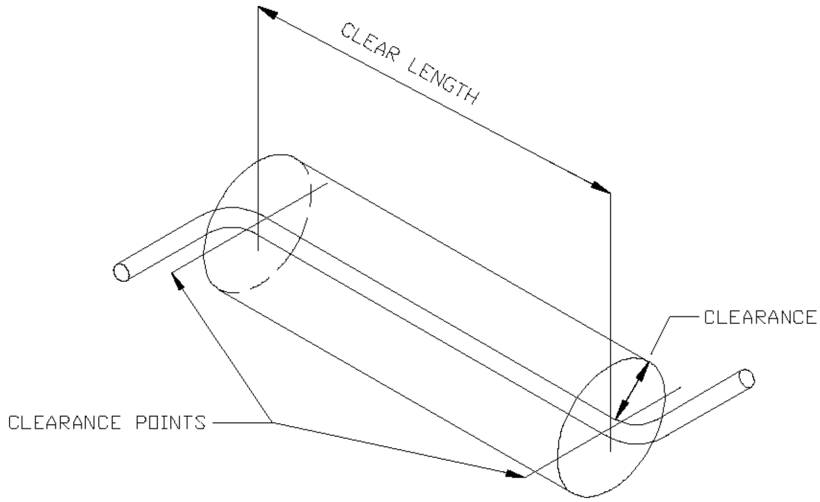
clear depth: As applied to step treads, clear depth is the distance measured vertically from the top surface of the tread to the closest obstruction anywhere within the specified minimum clear width and usable length. See **Figure 25**.

FIGURE 25
Sill Step Length and Clearances



clear length: As applied to handholds, clear length is that distance about which a minimum 2 in. (51 mm) hand clearance (from obstructions due to car design) exists in all directions around the handhold. The clear length of one portion of a handhold does not include handhold portions in other directions or bend radii connecting noncontinuous portions of a handhold. Intermediate supports may be considered part of the clear length. Unless otherwise stated, limitations on handhold length apply to the clear length. See **Figure 26**.

FIGURE 26
Clear Length of Handholds



clear width: As applied to step treads, clear width is the distance measured from the outboard surface of the tread to the closest inboard obstruction anywhere within the specified minimum clear depth and usable length. See **Figure 25**.

clearance points: As applied to handholds, clearance points are the ends of the clear length. See **Figure 26**.

collision post handhold: The handhold located at the end passageway of the vehicle to stabilize an employee when standing at the end of the car guiding reverse moves and to stabilize an employee when walking between cars.

crew handhold: The handhold used to assist an employee while entering or leaving a passenger entrance.

end handhold: The handhold located at the end of the vehicle to stabilize an employee when using the uncoupling device or as needed when connecting and disconnecting hoses and cables or when inspecting the vehicle.

fastener locking device: A device applied to a fastener to prevent the fastener from loosening.

handbrake, manually applied: A type of parking brake system where the brake force is applied and released by hand to prevent movement of a rail car such as a lever or wheel type handbrakes.

handhold: A device used for gripping or support when on steps or for assisting passengers and crew members when boarding or departing the vehicle. Handholds may be handrails.

handrail: Safety appliances installed on either side of a rail vehicle's exterior doors to assist passengers and crew members to safely board and depart the vehicle.

inboard: Toward the centerline of the car in either the transverse or longitudinal direction.

ladder: An arrangement of treads and/or handholds used for climbing to allow an employee to access equipment or perform a function that cannot be done from the ground.

longitudinal: Parallel to the centerline of track.

open platform car: A railcar with a non-enclosed section at the end of the car.

outboard: Away from the centerline of the car in either the transverse or longitudinal direction.

parking brake or handbrake (49 CFR §238.5 definition): A brake that can be applied and released by hand to prevent movement of a stationary railcar or locomotive.

parking brake system: A system applied to prevent a car from rolling due to gravity. This equipment shall include systems referred to as handbrakes or power assisted applied/release parking brakes.

passenger cars (49 CFR §238.5 definition): Rail rolling equipment intended to provide transportation for members of the general public and includes a self-propelled car designed to carry passengers, baggage, mail or express. This term includes passenger coach, cab car and MU locomotive. In the context of articulated equipment, "passenger car" means that segment of the rail rolling equipment located between two trucks. This term does not include a private car.

passenger equipment (49 CFR §238.5 definition):

1. All powered and unpowered passenger cars, locomotives used to haul a passenger car, and any other rail rolling equipment used in a train with one or more passenger cars. Passenger equipment includes—
    a. A passenger coach,
    b. A cab car,
    c. A MU locomotive,
    d. A locomotive not intended to provide transportation for a member of the general public that is used to power a passenger train, and
    e. Any non-self-propelled vehicle used in a passenger train, including an express car, baggage car, mail car, freight car, or a private car.
2. In the context of articulated equipment, "passenger equipment" means a segment of rail rolling equipment located between two trucks that is used in a train with one or more passenger cars. This term does not include a freight locomotive when used to haul a passenger train due to failure of a passenger locomotive.

passenger trainsets; passenger train (49 CFR §238.5 definition): A train that transports or is available to transport members of the general public. If a train is composed of a mixture of passenger and freight equipment, that train is a passenger train for purposes of this part.

prevailing-off torque: The torque measured when the fastener is being removed when there is zero axial load in the assembly.

railroad (49 CFR §270.5 definition):

1. Any….

roof handhold: Handhold located on the roof to be gripped for support when performing maintenance or inspections on the roof.

securely fastened: See Section 2.5, paragraph (2), for the definition of *securely fastened*.

semi-permanently coupled (49 CFR §238.5 definition): Coupled by means of a drawbar or other coupling mechanism that requires tools to perform the uncoupling operation. Coupling and uncoupling of each semi-permanently coupled unit in a train can be performed safely only while at a maintenance or shop location where employees can safely get under or between units.

side door handhold: Handhold located on the side of the car above a side door step.

side door step: Step or stirrup located on the side of the car to assist an employee in entering or leaving a side door entrance.

sill step: Step or stirrup located on the side, near the end of the car to allow an employee to ride on the side of the car during switching moves.

sill step handhold: Handhold located on the side of the car above a sill step.

transverse: Perpendicular to the centerline of the track in the horizontal plane.

uncoupling device: Mechanism used to uncouple cars without requiring an employee to go between cars.

usable length: As applied to sill steps, side door steps and step treads, usable length is the straight length, not including bend radii, above which the specified minimum clear depth exists. Unless otherwise stated, limitations on the length of sill steps and step treads apply to the usable length. See **Figure 25**.

Abbreviations and acronyms

AAR	Association of American Railroads
ATR	above top of rail
AWS	American Welding Society
CFR	Code of Federal Regulations
FRA	Federal Railroad Administration
IEC	International Electrotechnical Commission
NATSA	North American Transportation Services Association
SAE	Society of Automotive Engineers
SI	*Système international* (International System of Units)

Summary of document changes

- Document formatted to the new APTA standard format.
- Sections have been moved and renumbered.
- Scope and summary moved to the front page.
- Definitions, abbreviations and acronyms moved to the rear of the document.
- Two new sections added: “Summary of document changes” and “Document history.”
- Some global changes to section headings and numberings resulted when sections dealing with references and acronyms were moved to the end of the document, along with other changes, such as capitalization, punctuation, spelling, grammar and general flow of text.
- Participants updated.
- Abstract – Added non-passenger carrying locomotives to abstract.
- Scope and Purpose – Added “This standard is intended for only newly made passenger equipment but does not prevent application to re-built or overhauled passenger equipment.”
- Section 2.1 – Add requirement to inspect, repair and replace safety appliance in accordance with the requirements of this standard. Added requirement to account for vehicle manufacturing tolerances during safety appliance design.
- Section 2.3 – Added allowance of safety appliances made of wrought iron and alternate materials.
- Section 2.4 – Added section Strength and rigidity requirements.

- Section 2.5 – Added to the list of allowable securement methods.
- Section 3.1.1 – Added requirement parking brake requirement for semi-permanently coupled trainsets.
- Section 3.1.3.1 – Added 2 in. (51 mm) minimum hand clearance requirement for hand brake. Added requirement that the handbrake shall be placed to be safely operated while the car is in motion.
- Section 3.1.3.3 – Added center point location for wheel type handbrake.
- Section 3.1.3.4 – Added section Power-assisted applied/release parking brake.
- Section 3.2.1 – Added crew provisions to ride general exceptions for semi-permanently coupled, automatic coupler equipped, and self-propelled equipment.
- Section 3.2.2.1 – Removed minimum thickness requirement for sill steps. Added clear depth requirements for Tier III equipment. Added maximum vertical rise between treads. Added anti-skid area requirement.
- Section 3.2.2.2 – Removed allowance for steps exceeding 18 in. (457 mm) in depth. Added coordination of step to handhold in transverse direction. Added anti-skid area requirement.
- Section 3.2.3.2 – Added allowance for a passenger step to be used in lieu of a sill step. Adjusted maximum allowable ATR distance for lower handhold when two horizontal handholds are used. Raised height of handhold when only one horizontal handhold is used. Lowered highest clearance point and adjusted lowest clearance point where one vertical hand hold is used. Raised maximum lowest clearance point and adjusted the reference point of the highest clearance point of vertical handhold from ATR to above lowest step when both horizontal and vertical handholds are used; added recommendation that the vertical handhold be within the clear length of the step.
- Section 3.2.4 – Removed redundant dimensional requirements. Requirements are in Section 3.2.3.1.
- Section 3.3 – Added Section Crew Access.
- Section 3.3.1 – Added general requirements section for crew access.
- Section 3.3.1.1 – Adjusted minimum usable length requirement for crew access steps. Removed allowance for steps exceeding 18 in. (457 mm). Added tread surface area requirements.
- Section 3.3.1.2 – Added section Dimensions for Crew Access Handrails.
- Section 3.3.2 – Added Section Requirements for Crew Access at Low Level Floors.
- Section 3.3.3 – Added Section Requirements for Crew Access at High Level Floors with Inclined Steps.
- Section 3.3.4 – Added Section Requirements for Crew Access at High Level Floors with Vertical Steps or Ladders.
- Section 3.4.1 – Added handhold requirement exemption for equipment with automatic couplers.
- Section 3.4.4 – Added clearance point of the outboard end of the end handhold for non-passenger carrying locomotives. Added tapered nose equipment side of car determination criteria. Added maximum end handhold distance ATR and primary structure attachment allowance and uncoupling lever as end handhold allowance.
- Section 3.5.1 – Clarified two collision post requirement for cars with end passageways utilized to guide reverse moves.
- Section 3.6.3 – Added alternative handrail diameter allowance.
- Section 3.7.1 – Added automatic coupler equipped vehicle uncoupling device requirements.
- Section 3.7.3 – Adjusted maximum allowable distance of manual uncoupling levers from side of car and for cab ends with shrouding or aerodynamic treatment. Added preferred minimum clearance for uncoupling lever handle.
- 3.7.4 – Added location requirements for uncoupling levers for non-passenger carrying locomotives and uncoupling mechanisms for road locomotives with corner stairways. Added in-use remote control uncoupling mechanism location requirement.
- Section 3.8 – Added section Conditional safety appliances. This section includes the use of ladders in lieu or in combinations with side door steps and side door handholds.

- Section 3.8.1 – Added section Handholds and steps for appurtenances and windshields. This includes the use of ladders in lieu or in combinations with side door steps and side door handholds.
- Section 3.8.2 – Removed thickness requirement for ladder treads.
- Section 3.8.3.1 – Added function of general appliances for moving on side and end walls.
- Section 3.8.4.1 – Added section Stepping around the corner of a vehicle. This section contains dimension requirements.
- Section 3.8.5 – Added new section Rood handholds.
- Section 3.9 – Added new section Optional steps and handholds.
- Section 4 – Updated addresses of FRA and TC.
- Section 5 – Removed references to APTA PR-IM-S-007-98, Rev. 1 and reference to specific subsections under 49 CFR 238.
- References – Added references to EN 16116 and SAE J185.
- Definitions – Added definitions for 1) automatic coupler, 2) automatic coupler, fully, 3) cab, 4) cab, locomotive, 5) handbrake, manually applied, 6) handhold, 7) parking brake or handbrake, 8) parking brake system, 9) passenger cars, 10) passenger equipment, 11) passenger trainsets; passenger train, and 12) railroad. Removed definitions for handbrake, handrail, and parking brake. Modified definition for securely fastened.
- Updated Appendix A, Sample Car Inspection Checklist to reflect changes to the standard.
- Added Appendix B, Document Development Background, and Appendix C, Ergonomic Considerations.

Document history

Document Version	Working Group Vote	Public Comment/ Technical Oversight	Rail CEO Approval	Policy & Planning Approval	Publish Date
First published	—	—	—	May 18, 2007	June 2, 2007
First revision	Feb. 24, 2022	Mar. 31, 2022	Apr. 25, 2022	Jul. 8, 2022	Feb. 28, 2023

Appendix A (informative): Sample car inspection checklist

STANDARDS Driving Innovation in Public Transportation		Safety Appliance Design Review Checklist Edited: 1-17-18		
Reviewer:	Organization:		Date:	Region:
Builder:	Car Initials & Series:	Car Type:	Cars to be Built:	Builder Job #

HANDBRAKE/PARKING BRAKE

#	Number/Dimensions/Location/Manner of Application	APTA PR-M-S-016-06 Reference	Notes
General Requirements		3.1.1	
1	☐ Each individual car/semi-permanently coupled car has a handbrake or parking brake.		
1.a	☐ (Tier III only) Each trainset is equipped with a means of securing the equipment per 49 CFR 238.731(o).		
2	☐ If parking brake is used, it can be set from each car and can be released manually.		
Handbrakes, Lever or Wheel Type		3.1.3.1	
3	☐ Handbrakes are located so as to not restrict passenger flow through any passageway, whether applied or released and in their stored position.		
4	☐ Handbrakes are located so they can be safely operated while the car is in motion.		
5	☐ A handhold is provided to stabilize an employee when using the handbrake.		
Handbrake, Lever Type (Figure 3)		3.1.3.2	
6	☐ Center point of the pivot point of the lever is located 31 to 40 in. (788 to 1016 mm) above floor.		
7	☐ Handle retention mechanism does not interfere with the normal grip position of the lever.		
8	☐ The handbrake release lever has a minimum 2 in. (51 mm) hand clearance in the operating position.		
9	☐ The handbrake lever has a minimum 2 in. (51 mm) hand clearance in the stored position and a 24 in. (610 mm) body clearance on one side of the lever and a minimum 4 in. (102 mm) hand clearance on the opposite side and end in the operating position.		

#		Number/Dimensions/Location/Manner of Application	APTA PR-M-S-016-06 Reference	Notes
Handbrake, Wheel Type (Figure 4)			3.1.3.3	
10	☐	Center point of the wheel is located 31 to 40 in. (788 to 1016 mm) above floor.		
11	☐	The wheel type handbrake has a minimum 4 in. (102 mm) hand clearance.		
12	☐	The wheel diameter is at least 22 in. (559 mm).		
13	☐	If equipped, the hand brake manual release lever shall have a minimum 2 in. (51 mm) hand clearance.		
Parking Brake Only			3.1.3.4	
14	☐	Manual release lever has a minimum 2 in. (51 mm) hand clearance.		
Power Assisted Applied/Release			3.1.3.5	
15	☐	A readily accessible operational control mechanism is provided.		
Manner of Application			3.1.3.6	
16	☐	Handbrake housing and handbrake mounting brackets securely fastened.		

CREW PROVISIONS TO RIDE: SILL STEPS AND SILL STEP HANDHOLDS

#		Number/Dimensions/Location/Manner of Application	APTA PR-M-S-016-06 Reference	Notes
General			2.4	
16	☐	Securely fastened to the carbody structure.		
17	☐	Welds done in accordance with the standard and with proper welding procedures.		
Dimensions for Sill Steps			3.2.2.1	
18	☐	Minimum usable length 10 in. (254 mm).		
19	☐	Tread width no less than 2 in. (51 mm) wide.		
20	☐	Minimum clear depth, 8 in. (204 mm).		
20.a	☐	(Tier III only) Minimum clear depth 4.7 in. (120 mm).		
21	☐	Minimum clear width 6 in. (153 mm) with trucks rotated to simulate the maximum curvature specified for the uncoupled car.		
22	☐	Vertical rise between treads does not exceed 18 in. (457 mm).		
23	☐	The portion of the tread surface normally contacted by the foot is treaded with an anti-skid material or is slip resistant by texturing of the metal surface. Enclosed step designs have at least 50% of the tread area as open space.		

#		Number/Dimensions/Location/Manner of Application	APTA PR-M-S-016-06 Reference	Notes
24	☐	10 × 8 × 6 in.(254 × 208 × 153 mm) test box passes through opening above each sill step, so box is flush with outer edge of step.		
24.a	☐	(Tier III only) 10 × 4.7 × 6 in. (254 × 120 × 153 mm) test box passes through opening above each sill step, so box is flush with outer edge of step.		
Location for Sill Steps			3.2.2.2	
25	☐	One sill step is located at each corner of the car. A passenger step may be used in lieu of a sill step if it meets the clear depth, clear width, usable length and location requirements for a sill step.		
26	☐	Outboard end of the usable length is a minimum 18 in. (457 mm) in the longitudinal direction from the corner of the car. For cars without well-defined corners, the intent is for the sill step to be positioned for the employee to have an unobstructed view of the track ahead. The sill step shall be placed so the employee has a clear view in both longitudinal directions and shall be placed outside the gauge of the track.		
27	☐	Sill step tread is a maximum 24 in. (609 mm) ATR.		
28	☐	Outside edge of any sill step tread is a maximum 7 in. (177 mm) inboard or outboard of the inside surface of the lowest adjacent side handhold.		
29	☐	The outside edge of any sill step tread is no more than 2 in. (50 mm) (4 in. (101 mm) if clearance diagram does not allow 2 in. and if the step tread is a maximum 21 in [533 mm] ATR) inboard of any car structure in the area between 0 and 24 in. (0 and 609 mm) above the top of the step.		
Dimensions for Sill Step Handholds			3.2.3.1	
30	☐	Minimum diameter ⅝ in. (16 mm).		
31	☐	Minimum clear length 16 in. (407 mm).		
32	☐	Minimum clearance 2 in. (51 mm).		
Location for Sill Step Handholds			3.2.3.2	
33	☐	Minimum of two handholds over each sill step. If it is not possible to place two handholds over a sill step, there shall be at least one handhold over that sill step, and the railroad shall prohibit employees from riding on that sill step.		
34	☐	If a passenger step is used in lieu of a sill step, handholds are provided in accordance with Section 3.2.4.		
Horizontal Sill Step Handholds Only				
35	☐	If two horizontal handholds are used, one handhold is a maximum 54 in. (1371 mm) ATR. Second handhold is 54 to 58 in. (1372 to 1473 mm) above the lowest (riding) step. **(Figure 7)**		

#	Number/Dimensions/Location/Manner of Application	APTA PR-M-S-016-06 Reference	Notes
36	☐ If one horizontal handhold is used, it is 58½ to 64½ in. (1486 to 1638 mm) ATR. **(Figure 8)**		
37	☐ 12 in. (305 mm) of the clear length of the handhold(s) is directly over the sill step.		
Vertical Sill Step Handholds Only			
38	☐ If two vertical handholds are used, the lowest clearance point of each is a maximum 58½ in. (1485 mm) ATR. Highest clearance point of each is at least 58 in. (1474 mm) above the lowest (riding) step. **(Figure 9)**		
39	☐ Each set of vertical handholds is spaced 16 to 22 in. (407 to 558 mm) apart. **(Figure 9)**		
40	☐ If one vertical handhold is used, then the lowest clearance point is a maximum 58½ in. (1485 mm) ATR. Highest clearance point is at least 58 in. (1474 mm) above the lowest (riding) step. **(Figure 10)**		
41	☐ Inside face of the outboard handhold maximum 2 in. (50 mm) outboard of the inside face of the outboard vertical leg of the step Inside face of the outboard handhold minimum 10 in. (254 mm) outboard from the inside face of the inboard vertical leg. **(Figure 10)**		
Combination Sill Step Handholds Only			
42	☐ When a combination of horizontal and vertical handholds is used, the horizontal handhold is 54 to 58 in. (1372 to 1473 mm) above the step. Lowest clearance point of the vertical handhold is a maximum 54 in. (1371 mm) ATR. Highest clearance point of the vertical handhold is a minimum 70 in. (1778 mm) ATR. **(Figure 11)**		
Handholds for Riding at Passenger Steps (Figure 12)		3.2.4.3	
43	☐ Two vertical handholds, one on each side of the door opening.		
44	☐ The lowest clearance point of each crew handhold is 54 in. (1372 mm) ATR.		
45	☐ If the crew handhold is located outside the door opening, the crew handhold is located no more than 6 in. from the vertical inside face of the door opening.		

CREW ACCESS: STEPS AND HANDHOLDS

#	Number/Dimensions/Location/Manner of Application	APTA PR-M-S-016-06 Reference	Notes
General Requirements		3.3.1	
46	☐ A minimum of one crew access location per car side		
47	☐ A minimum of two crew access locations per side per set of semi-permanently coupled passenger cars, provided that each location provides access to all the passenger and crew areas of the set.		
48	☐ Crew access steps and handholds are provided on any carbody side door directly leading into a cab or machinery compartment		
48.a	☐ (Tier III only) Tier III trainsets may use portable ladders equipped with handrails.		
49	☐ Securely fastened to the carbody structure.	2.4	
50	☐ Welds done in accordance with the standard and with proper welding procedures.		
Dimensions for Crew Access Steps		3.3.1.1.	
51	☐ Minimum usable length 10 in. (254 mm)		
52	☐ Tread width no less than 2 in. (51 mm) wide.		
53	☐ Steps do not have a vertical rise between treads exceeding 18 in. (457 mm). Additional treads are provided if needed.		
54	☐ Minimum clear depth of lowest side door step 8 in. (204 mm)		
55	☐ Minimum clear depth of all side door steps except lowest 6 in. (153 mm)		
55.a	☐ (Tier III only) Minimum clear depth of all steps is 4.7 in. (120 mm).		
56	☐ Minimum clear width is 6 in. (153 mm), with trucks rotated to simulate the maximum curvature specified for the uncoupled car.		
57	☐ The portion of the tread surface normally contacted by the foot is treaded with an anti-skid material or is made slip-resistant by texturing of the metal surface. Enclosed steps designs have at least 50% of the tread area as open space.		
58	☐ 10 × 8 × 6 in. (254 × 204 × 153 mm) test box passes through opening above the lowest side door step, so box is flush with outer edge of step.		
59	☐ 10 × 6 × 6 in. (254 × 153 × 153 mm) test box passes through opening above all side door steps except the lowest, so box is flush with outer edge of step.		
59.a	☐ (Tier III only) 10 × 4.7 × 6 in. (254 × 120 × 153 mm) test box passes through opening above all side door steps, so box is flush with outer edge of step.		

#	Number/Dimensions/Location/Manner of Application	APTA PR-M-S-016-06 Reference	Notes
Dimensions for Crew Access Handrails		3.3.1.2	
60	☐ Minimum diameter ⅝ in. (16 mm)		
61	☐ Minimum clear length 24 in. (610 mm)		
62	☐ Minimum clearance 2 in. (51 mm)		
63	☐ In interior handrails also used for passenger access, the diameter and minimum clearance around the vertical handrail shall comply with §38.97(a) or 38.115(a).		
Requirements for Crew Access at Low-Level Floors (Figure 13)		3.3.2	
64	☐ Additional crew access steps are not needed where the door threshold is at a height not more than 24 in. (609 mm) ATR.		
65	☐ At least one vertical handhold on one side of the door opening, inside the car or on the door frame, not more than 9 in. (228 mm) from the outside face of the door opening.		
66	☐ The lowest clearance point of the vertical handrail shall be at most 58½ in. (1485 mm) ATR.		
Requirements for Crew Access at Inclined Steps (Figure 14)		3.3.3	
67	☐ The first (lowest) crew access step is not more than 24 in. (609 mm) ATR.		
68	☐ For designs that have inclined steps with the lowest step more than 24 in. (609 mm), additional crew access steps and handholds are applied in accordance with Section 3.3.4.		
69	☐ There is at least one vertical handhold on the side of the door opening.		
70	☐ The lowest clearance point of the vertical handhold is at least 58½ in. (1486 mm) ATR.		
71	☐ There is a second handhold provided to facilitate stepping up into the car.		
72	☐ If the crew handhold is located outside the door opening, the crew handhold is located no more than 6 in. (152 mm) from the vertical inside face of the door opening.		

#	Number/Dimensions/Location/Manner of Application	APTA PR-M-S-016-06 Reference	Notes
Requirements for Crew Access at Vertical Steps or Ladders (Figure 15)		3.3.4	
73	☐ For side door steps that extend beyond the side door opening in the longitudinal direction, the inside face of the leg of side door step located under the door opening is minimum 10 in. (254 mm) in the longitudinal direction from the vertical inside face of the door opening. Inside face of opposite leg of the side door step is located on the centerline of the side door handhold or extends beyond it.		
74	☐ Side door step tread maximum 24 in. (609 mm) ATR.		
75	☐ Outside edge of any side door step tread is a minimum 6 in. inboard or outboard of the inside surface of the lowest adjacent side handhold.		
76	☐ The outside edge of any sill step tread is no more than 2 in. (50 mm) (4 in. (101 mm) if the clearance diagram does not allow 2 in. (50 mm) and if the step tread is a maximum 21 in. (533 mm) ATR) inboard of any car structure in the area between 0 and 24 in. (609 mm) above the top of step within the clear length of the step.		
77	☐ The outside edge of any crew access steps is no more than 3 in. (76 mm) inboard of the door threshold. If the door threshold used to mitigate the horizontal gap between the car and platform does not allow this 3 in. (76 mm) requirement to be achieved, up to 7 in. (177 mm) is permitted.		
78	☐ One interior or exterior vertical crew access handhold over each crew access step located between the inside faces of the legs of the crew access step. If an exterior handhold is used, then an additional interior handhold is provided to facilitate stepping up into the car.		
79	☐ The lowest clearance point of the crew access handhold is at most 58½ in. (1485 mm) ATR.		
80	☐ An exterior crew access handhold is located no more than 6 in. (152 mm) from the vertical inside face of the door opening.		
81	☐ When ground access is provided for cabs or machinery compartments, two vertical side door handrails are provided, one on each side of the door, to continue to a point at least 60 in. (1524 mm), or as high as practicable based on carbody design, above the floor of the cab at the door entrance. For Tier III equipment, the handholds shall continue to a point at least 48 in. (1220 mm, or as high as practicable based on carbody design, above the cab floor at the door entrance.		

END HANDHOLDS (Figure 19)

#	Number/Dimensions/Location/Manner of Application	APTA PR-M-S-016-06 Reference	Notes
82	☐ Two horizontal end handholds are located on each end of a vehicle or trainset unit equipped with an automatic coupler, one near each side on each end projecting downward from the face of the end sill or sheathing.	3.4.1	
83	☐ Minimum diameter ⅝ in. (16 mm)	3.4.3	
84	☐ Minimum clearance 2 in. (51 mm)		
85	☐ Minimum clear length 16 in. (407 mm)		
86	☐ Securely fastened to the carbody structure.		
87	☐ Welds done in accordance with the standard and with proper welding procedures.		
88	☐ Clearance point of the outboard end of the end handhold is maximum 16 in. (406 mm) from side of car for passenger-carrying vehicles.	3.4.4	
89	☐ Clearance point of the outboard end of the end handhold is maximum 8 in. (203 mm) from side of car for non-passenger carrying vehicles.		
90	☐ If the equipment is designed with a tapered nose, the side of the car is determined based on the outer dimensions of the tapered nose where the end handhold is attached.		
91	☐ The handholds are located not greater than 50 in. (1270 mm) from top of rail. Handholds may be attached to any primary structure (e.g., carbody frame; or pilot, or plow on cab cars).		
92	☐ An uncoupling lever may be used as an end handhold if it otherwise meets the requirements for end handholds		

COLLISION POST HANDHOLDS (Figure 20)

#	Number/Dimensions/Location/Manner of Application	APTA PR-M-S-016-06 Reference	Notes
93	☐ Two vertical collision post handholds at each end passageway.	3.5.1	
94	☐ Securely fastened to the carbody structure.	2.4	
95	☐ Welds done in accordance with the standard and with proper welding procedures.		
96	☐ Minimum diameter, ⅝ in. (16 mm)	3.5.3	
97	☐ Minimum clearance, 2 in. (51 mm)		
98	☐ Lowest clearance point, maximum 44 in. (1117 mm) above the walkway.	3.5.4	

99	☐ Highest clearance point, minimum 60 in. (1524) above the walkway.		

HANDRAIL ON OPEN PLATFORM CARS (Figure 21)

#	Number/Dimensions/Location/Manner of Application	APTA PR-M-S-016-06 Reference	Notes
100	☐ Platform area enclosed with either a handrail or shortened walls.	3.6.1, 3.6.4	
101	☐ Railing and stile assembly may be welded, but the ends of the final assembly must be securely fastened to the carbody structure.	3.6.4	
102	☐ Welds done in accordance with the standard and with proper welding procedures.	2.4	
103	☐ Minimum handrail diameter 1 in. (26 mm)	3.6.3	
104	☐ Minimum wall thickness $^1\!/_{16}$ in. (2 mm)		
105	☐ If intermittent handrail is used, end of the handrail is capped with a rounded end to reduce risk of injury.	3.6.4	
106	☐ Maximum distance from end of handrail to a vertical car member 4 in. (101 mm)		
107	☐ Minimum length from top of the platform floor to the top of the handrail, including entry doors, 42 in. (1067 mm)		
107	☐ Handrail designed such that a 5 in. (127 mm) diameter ball cannot pass through any space between handrail members or between the handrail and the carbody.		
108	☐ Handrail members shall not be unsupported for spans over 48 in. (1219 mm)		
109	☐ If shortened wall is used, it meets the location requirements for handrails as detailed above.		

UNCOUPLING DEVICES (Figure 22)

#	Number/Dimensions/Location/Manner of Application	APTA PR-M-S-016-06 Reference	Notes
110	☐ Each car equipped with an automatic coupler has either a manual uncoupling device at each end of the car, located so it can be operated from the left side of the car as seen when facing the end of the car from the ground, an uncoupling mechanism operated by remote controls.	3.7.1 3.7.4	
111	☐ Each non-passenger-carrying locomotive end equipped with an automatic coupler has either a manual double-lever uncoupling lever, operative from either side of the locomotive, or an uncoupling mechanism operated by remote controls.	3.7.1 3.7.4	
112	☐ Road locomotive with corner stairways are equipped with uncoupling mechanisms that can be operated safely from the bottom stairway opening or end platform area when		

	the mechanism is in its normal position or when it is operated.		
113	☐ Securely fastened to the carbody structure.	2.4	
Only if Mechanically Operated from Side of Car		3.7.3	
114	☐ Under all operating conditions, outside surface of uncoupling device handles is not more than 12 in. (304 mm) from the side of the car or, for cab ends with shrouding or aerodynamic treatment, from the outer dimension of the tapered nose where the end handhold is located.		
115	☐ Uncoupling attachments are applied so they can be operated by a person standing on the ground.		
116	☐ Bottom end of the handle is between 12 (305 mm) and 15 in. (318 mm) below the centerline of the outermost pivot point of the uncoupling lever to which the handle is attached.		
117	☐ Minimum 2 in. (51 mm) clearance around the handle at its end.		
118	☐ Securely fastened to the carbody structure or supporting bracket.	3.10.5	

OPTIONAL SAFETY APPLIANCE: LADDERS

#	Number/Dimensions/Location/Manner of Application	APTA PR-M-S-016-06 Reference	Notes
119	☐ Securely fastened to the carbody structure.	2.4	
120	☐ Welds done in accordance with the standard and with proper welding procedures.		
121	☐ Minimum usable length 16 in. (407 mm) on side ladders and 14 in. (356 mm) on end ladders.	3.8.2.3	
122	☐ If rectangular cross section, treads are minimum 2 in. (51 mm) wide.		
123	☐ If circular cross-section, minimum tread diameter is ⅝ in. (16 mm)		
124	☐ Minimum tread clearance 2 in. (51 mm)		
125	☐ All ladder treads have foot guards.		
126	☐ Top ladder tread is between 12 and 18 in. (305 to 457 mm) (below the mounting surface of the outboard end of the adjacent roof handhold.	3.8.2.4	
127	☐ Maximum spacing between ladder treads is 19 in. (482 mm)		
128	☐ Spacing of side ladder treads is uniform within a limit of 2 in. (51 mm), from top ladder tread to bottom tread of ladder.		

Appendix B (informative): Document development background

The original APTA working group that developed this safety standard included an ergonomics professional. The ergonomics professional advised APTA that riding a sill step when holding on to a single handhold is difficult in some operating circumstances. As a result, the standard requires two handholds placed at an ergonomically acceptable distance apart above each sill step on new cars.

This caused controversy because many car designs have doors near the corner of the car that would preclude the placement of the second handhold an ergonomically acceptable distance from the first handhold.

Some passenger railroads currently prohibit their employees from riding sill steps because they believe the employees are safer riding inside the car or walking beside the car during switching moves. APTA surveyed 18 passenger railroads; 16 of them either currently have operating rules that prohibit riding sill steps or strongly discourage riding sill steps and would be willing to implement such an operating practice.

As a result of this survey, APTA considered an option to eliminate sill steps if the railroad has in place an operating practice that prohibits their use. The best way to enforce this operating practice is to eliminate the sill step. Employees cannot use what is not there. This solves the door-near-the-corner-of-the-car design problem. If a railroad wishes to operate equipment of this design, that railroad must either ban riding the sill step or determine a way to install a second handhold above the sill step an ergonomically correct distance from the first handhold.

The standard requires a sill step and two corresponding handholds an ergonomically correct distance apart for all new equipment. If a railroad wishes to procure new equipment designs where placement of two handholds above the sill step is not possible, that railroad may do so if it adopts an operating practice that prohibits riding that sill step.

This new requirement accomplishes two important things:

- For new equipment, railroad employees are provided the extra safety of a second handhold, or they are not allowed to expose themselves to the danger of riding a sill step equipped with only one handhold.
- Railroads can continue to purchase equipment designs with corner doors.

As with all compromises, the new requirement has a downside: A sill step with a single handhold must be provided even when the railroad bans riding the sill step. From a railroad’s perspective, this does not make sense. But it gained the FRA, Transport Canada and labor support necessary for APTA to go forward. This compromise answers labor’s concern over the interchange of equipment without sill steps between passenger railroads and hauling such passenger cars in freight trains. Overall safety of railroad employees will increase with time as more cars with two handholds above sill steps enter the fleet.

Appendix C: Ergonomic considerations

There is a concern that a worker could step down to the ground from a moving car and be struck by part of the same car or the next car moving toward the worker. A 1st percentile female for the horizontal measurement and a 99th percentile male vertical measurement were used as conservative parameters for clearance. These will ensure that the shorter person will be clear of the car as the car side passes by and that the taller person will not hit his or her head on a low load. The figure below is representative of the posture assumed by individuals getting off equipment.

FIGURE 27
1st Percentile Female Ergonomics

Figure 27 depicts a body position at its maximum height from the top of rail (24 in.), which will place the person higher closer to the car side. The body position above shows a 1st percentile female with a horizontal distance from the ladder of approximately 18 in. This is approximated, because it could be less or more depending on the actual body position. FRA's Research and Development Division noted that many engineering designs employ a safety margin to lessen the likelihood of failure. In most cases, a factor of 2 is applied. In the present instance, that would reduce the acceptable inboard distance from 18 to 9 in. The safety margin could help to ensure that once the employee has fully contacted the ground, all parts of the body would have cleared 9 in. before a piece of equipment occupied the same space. When getting off moving equipment, the motion of the car transfers momentum to the employee, so clearing 9 in. is a safe margin.

According to the US Army Natick anthropometric tables, a 99th percentile male is 75 in. in height. Subtracting 9 in. for the height of the rail, FRA recommends that the protrusion of the car should be no lower than 66 in. ATR. This point in space then is 66 in. from top of rail and 9 in. in from the clearance diagram.

Appendix D: Explanatory material

NOTE: This appendix is not part of the requirements of this APTA standard and is included for informational purposes only. This appendix contains explanatory material, numbered to correspond with the applicable text paragraphs. The C stands for commentary.

C.2.4

1.b. The intent of allowing for alternate material sections in 1.b. is to allow different geometries to be used in the step instead of a solid uniform cross-section. For example, an expanded metal or serrated type step that does not have uniform cross section. It is also to allow for thinner cross section if a stronger base material is utilized.
1.b. only applies to wrought iron, steel or stainless steel of equivalent strength as defined in Section 2.3.

1.c. The purpose of the additional tread and lateral bracing is historically required by the CFR and is necessary to provide rigidity. See also 3.2.2.1.

2.e. To establish baseline acceleration requirements for the carbody, the following standards were reviewed. The most conservative acceleration was selected, Category L from EN 12663-1.

- EN 12663-1, Railway applications – Structural requirements of railway vehicle bodies – Part 1: Locomotives and passenger rolling stock (and alternative method for freight wagons). Tables 16 thru 18 were reviewed for category L for locomotives and Category P-I and P-II for passenger rolling stock.

Orientation	Acceleration Category L	Acceleration Category P-I/P-II
Vertical	±0.25 g	±0.15 g
Transverse	±0.20 g	±0.15 g
Longitudinal	±0.15 g	±0.15 g

- IEC 61373, Railway applications – Rolling stock equipment – Shock and vibration tests. A service vibration environment can be calculated by using the 3-sigma values from Category 1, Class A, functional service level RMS acceleration.

	Acceleration (m/s^2)	
Orientation	**RMS from IEC 61373[1]**	**Analysis**
Vertical	0.750	±2.25 (±0.23 g)
Transverse	0.370	±1.11 (±0.11 g)
Longitudinal	0.500	±1.50 (±0.15 g)

1. Assume fully reversing amplitudes based on RMS value and that the RMS value = sigma.

C.3.2.2.1 Dimensions for sill steps

(1) Regarding the minimum usable length of the tread, the 12 in. (305 mm) length is in line with EN 16116, which specifies 300 mm as the clear length

C.3.2.2.2 Location

(5) The maximum dimension of 7 in. for aligning the step with the handhold the transverse direction was chosen to accommodate cars with very strict clearance diagrams, such as equipment running the US Northeast

or running in third-rail territory (Amtrak, Long Island Rail Road, Metro-North Railroad, etc.). Assuming a 10 ft, 6 in., carbody width, the maximum could be around 7 in., based on review of the LIRR clearance diagram.

C.3.2.3.2 Location

(6) It is important to set the minimum highest clearance point with respect to the lowest step, as the crew will only ride on the lowest step.

(8) The highest clearance point of the vertical handholds was changed from 70 in. ATR in the previous version of this standard to 52 in. from the lowest riding step to ensure a 16 in. minimum clear length of the handhold. The 52 in. allows for a minimum 17½ in. clear length and at least 2 in. of spacing between the vertical and horizontal handholds.

C.3.3.1

(5) The allowance for portable ladders is included in the latest Engineering Task Force (as part of FRA's Rail Safety Advisory Committee) language for safety appliances. It is anticipated that this language will be incorporated into the Code of Federal Regulations during a future rulemaking.

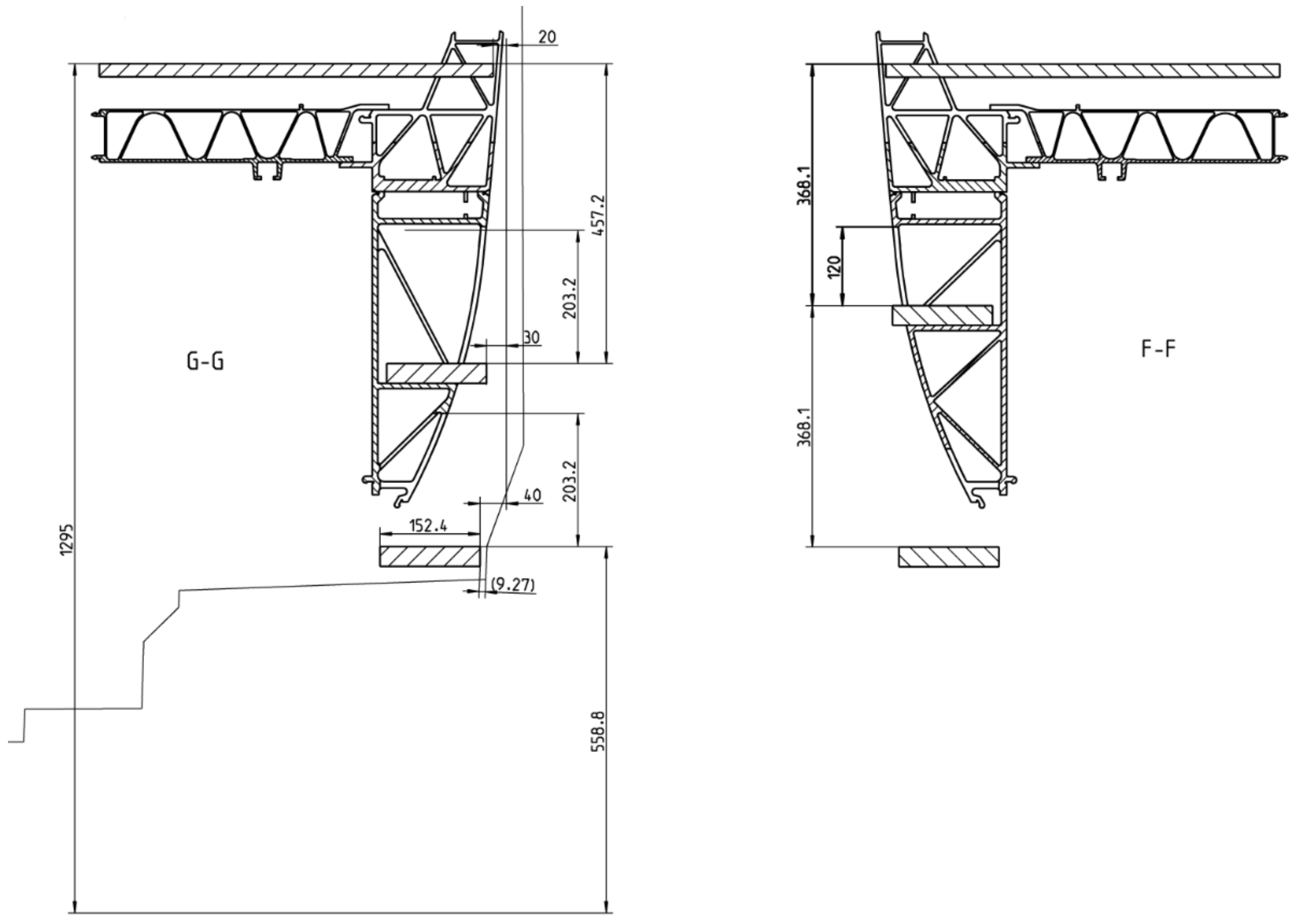
C.3.3.1.1

(4) There were questions raised as to why the clear depth for all other steps other than the lowest step was allowed to be only 6 in. (152 mm) instead of 8 in. (203 mm) required for the lowest step.

The working group researched minimum clear depth requirements for other industries and identified that 6 in. (152 mm) is acceptable. EN 16116 requires a minimum 150 mm (5.91 in.) for shunting type power units and 120 mm (4.7 in.) for other vehicle tapes. 29 CFR 1910.266 specifies SAE J185 for off-road machinery. SAE J185 Table 1 indicates (5.91 in.), a minimum of 15 mm for instep and toe clearance.

The group also determined that the 6 in. allowance for steps other than the lowest step is necessary due to certain car constructions with a 51 in. floor height and traditional closed box side sill construction. To maintain an 18 in. maximum vertical rise, a 6 in. clear depth in some cases may be necessary. See **Figure 28**.

FIGURE 28
Crew Access Step Clear Depth Evaluation



C.3.3.4.2

(4) The standard allows a lower handhold height above the cab floor for Tier III equipment. This reduction was considered due to Tier III aerodynamic end car designs that may limit the height above cab floor for the handholds. The working group considered 48 in. (1219 mm) in line with EN 16116, which requires 1200 mm (47 in.) for shunting locomotives and 1000 mm (39 in) for all other types. In addition, the elbow height for a 95th percentile male is approximately 45 to 47 in.

C.3.8 Conditional safety appliances

The working group changed the language from “optional” to “conditional” to use wording that was more reflective of the requirements of these safety appliances. This wording also matches the latest Engineering Task Force language (as part of FRA’s Rail Safety Advisory Committee) for safety appliances. It is anticipated that this language will be incorporated into the Code of Federal Regulations during a future rulemaking.

APTA STANDARDS DEVELOPMENT PROGRAM
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PRESS Mechanical Working Group

Low-Speed Curving Performance of Railroad Passenger Equipment

Abstract: This standard contains requirements for evaluating low-speed vehicle curving performance of railroad passenger equipment.

Keywords: derailments, low-speed curving performance, multi-body simulations, rail vehicle dynamics, suspension, track twist, warp, wheel climb, wheel load equalization, wheel unloading

Summary: This standard defines vehicle and track conditions to evaluate the ability of passenger equipment to resist wheel climb derailments when operating at low speeds over track curves with high-degree of curvature. The methodology in this standard shall be used for simulations conducted using industry-accepted rail vehicle dynamics software.

Scope and purpose: This standard defines an evaluation methodology to minimize the risk of low-speed derailments for passenger equipment. It shall apply to railroad passenger equipment as defined in 49 CFR 238.5, originally contracted on or after one year from the date of publication, or sooner as specified by the railroad as defined by 49 CFR 270.5.

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Introduction

This introduction is not part of APTA PR-M-S-xxx-19, "Low-Speed Curving Performance of Railroad Passenger Equipment."

This document is part of a series of APTA standards designed to mitigate railroad passenger equipment derailment concerns. Specifically, it is designed to address potential risks from derailment under conditions of slow operating speeds in tight-radius curved track with large rail-to-rail cross level (track warp) variations. In response to occurrences of rail vehicle derailments in the field under such track geometry conditions which were within limits of the Federal Railroad Administration (FRA) Track Safety Standards, the FRA in 2013 issued Safety Advisory 2013-02 to alert railroads and other industry members of the potential for low-speed, wheel-climb derailments of certain passenger equipment designs. Findings from derailment investigations conducted by the FRA and railroads have highlighted the need to ensure that passenger equipment suspension systems are suitable for demanding track conditions found in low-speed operating environments. The industry recognized that this is a potential concern for all equipment designs, and this standard is a result of these findings.

A subset of this Safety Advisory recommends that the industry evaluate the trackworthiness performance of passenger equipment on track with high degree of curvature and limiting values of track warp. This standard is the third in a series of complementary APTA standards for passenger equipment operating on passenger rail lines or freight rail lines specifically designed to work together to provide greater confidence in the safe operation of trains under these conditions. The other two related standards set minimum wheel flange angle (APTA PR-M-S-015, latest revision) and establish wheel load equalization performance criteria (APTA PR-M-S-014, latest revision).

This standard applies to all:

1. Railroads that operate intercity or commuter passenger train service on the general railroad system of transportation; and
2. Railroads that provide commuter or other short-haul rail passenger train service in a metropolitan or suburban area, including public authorities operating passenger train service.

This standard does not apply to:

1. Rapid transit operations in an urban area that are not connected to the general railroad system of transportation;
2. Tourist, scenic, historic, or excursion operations, whether on or off the general railroad system of transportation;
3. Operation of private cars, including business/office cars and circus trains; or
4. Railroads that operate only on track inside an installation that is not part of the general railroad system of transportation.

Low-Speed Curving Performance of Railroad Passenger Equipment

1. Overview

Safe performance of railroad passenger equipment is the result of several design and maintenance factors. These generally fall into the four categories listed below: track conditions, vehicle conditions, wheel/rail interface and individual railroad operating practices:

- Track conditions:
    - entry and exit spirals
    - degree (radius) of curvature
    - track geometry as per 49 CFR 213(alignment/profile/cross-level)
    - track superelevation
    - track gage
    - friction modifiers
    - rail profile (new/worn)
    - cant deficiency/cant excess
- Vehicle conditions:
    - loading condition
    - suspension characteristics (new/degraded)
    - wheel profile (new/worn)
    - truck frame torsional stiffness
    - rail vehicle height and center of gravity
    - wheel load equalization
    - truck rotational resistance
    - carbody stiffness
- Wheel/rail interface:
    - tread conicity
    - wheel/rail contact angle
    - tread friction coefficient
    - flange friction coefficient
- Operation:
    - vehicle speed
    - in-train forces (buff/draft)

While this document does not address all the above factors, it focuses on track warp in high-degree curves, as these aspects are known to have contributed to many derailments. As such, representative track scenarios involving limiting warp conditions are to be analyzed using computer simulations and model validations as described within this document.

2. Low-speed curving performance requirements

Optimal design characteristics for high-speed operations may not result in satisfactory performance at low speeds (e.g., on Class 1 tracks), especially in curves. Balancing high-speed and low-speed performance requirements is a challenging design optimization problem. This standard provides a method to evaluate low-speed curving performance during the equipment design and qualification process. Simulation requirements, including modeling and model validation, are described herein to provide a proven and consistent method to evaluate low-speed curving performance.

2.1 Modeling software requirements

Vehicle low-speed curving response through a track twist input is to be predicted using railway industry-standard multi-body simulation software as approved by the railroad. At minimum, the software must represent the vehicle as a system of masses and suspension elements and include a wheel-rail interaction model. The wheel-rail model must consider contact geometry variations arising from the transition between tread contact to flange contact, the possibility of multiple contact points at a flanging wheel, and the effect of friction saturation at any contact point. The multi-body simulation models built with such software shall represent the vehicle design adequately. As an example, when modeling a primary suspension with a swing arm (or radius arm), the model should accurately account for the coupling between axle box vertical and longitudinal motion that results in a change in overall vertical suspension stiffness.

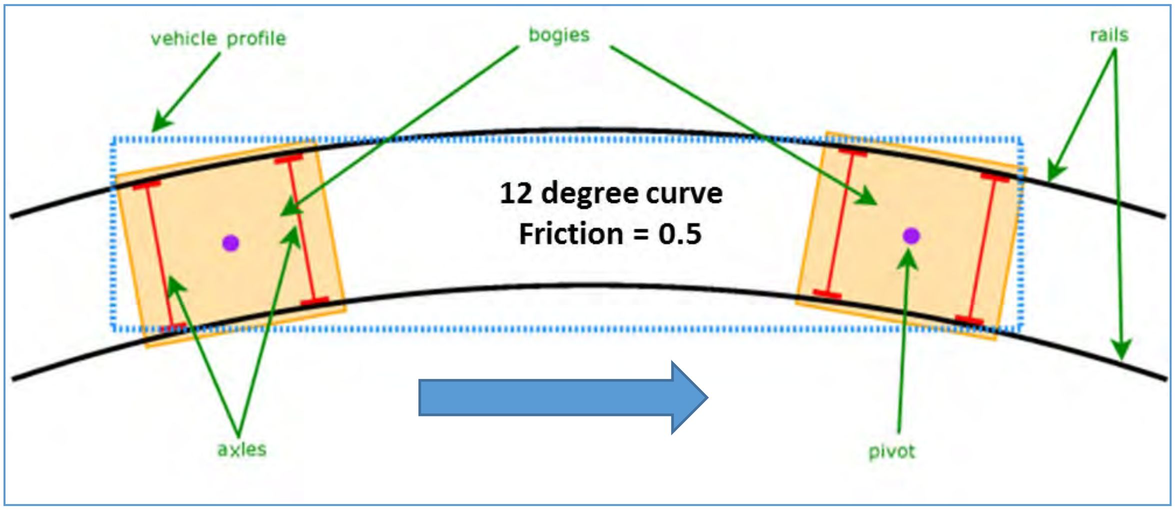
2.2 Track parameters

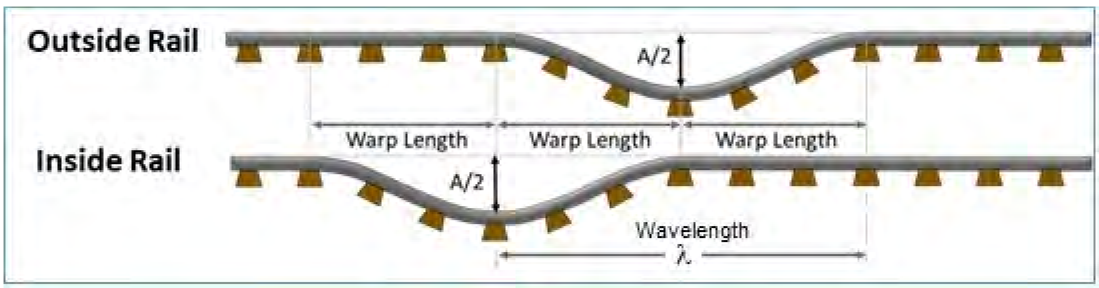
For each simulation involving assessment of curving performance in this standard, the degree of curvature shall be 12 deg. and the superelevation equal to zero. The basic layout of the curved track section is shown in **Figure 1**. The body of the curve shall contain a pair of versine profile (track surface) deviations to produce the amplitude associated with a maximum permissible warp threshold for Class 1 track derived from the 3 inches[1] mentioned in 49 CFR 213.63(a). The special layout of these perturbations begins on the inside rail, followed by perturbation on the outside rail separated by a distance referred to as the warp length. Each deviation has a wavelength, λ, defined as twice the warp length. Separate simulations shall be used to study warp lengths of 10, 20, 40 and 62 ft. All simulations shall be performed using a new American Railway Engineering and Maintenance-of-Way Association (AREMA) 136 RE (8” head radius) rail profile with a 1:40 rail cant and a nominal track gage of 57.0 in.

> **NOTE:** Additional simulations may be considered if the actual new rail profile and/or nominal cant used on a particular railroad differs from the AREMA 136 RE (8” head radius) and 1:40 rail cant specified above. In addition, it is important to note that worn rail profiles (particularly heavily curved worn rails) can result in a maximum contact angle between wheel and rail that is lower than the maximum wheel flange angle and therefore increase the risk of low-speed wheel climb derailments. These additional rail profile considerations should be included based on an agreement between the railroad and carbuilder.

[1] Perturbation thresholds and wavelengths were utilized from the FRA Safety Advisory 2013-02

FIGURE 1
Track Parameters





2.3 Vehicle parameters

Simulations using the vehicle model shall consider variations of vehicle parameters (e.g., mass, center of gravity, and moments of inertia) to accurately represent the conditions defined in **Table 1**.

TABLE 1
Vehicle Parameters

Parameter	Condition
Vehicle load	AW0 (empty ready to run[1]) AW3 (fully loaded[1]) Additional worst-case condition between AW0 and AW3, if applicable (e.g., nonlinear vertical suspension), as determined by the carbuilder[2]
Suspension system	Nominal condition Deflated air spring condition, if applicable[3] Evaluation of critical suspension components with tolerances greater than 15 percent[2]

1. As per definition of the railroad.
2. These evaluations shall be conducted using additional simulations to be defined by an agreement between the carbuilder and railroad.
3. The only failure to be considered is with all air springs deflated.

The vehicle model shall be correlated with test results as per the model validation process defined in Section 2.7.

NOTE: If the carbuilder uses the structural flexibility of the carbody, truck frame or any other body to achieve the performance requirements in this standard, a detailed description and justification based on testing under section 2.7.2 (c) (truck twist and vehicle twist) shall be provided in the report as required in Section 2.8.

2.4 Wheel/rail interface parameters

In addition to the track parameters defined under Section 2.2 and vehicle parameters defined under Section 2.3, the following wheel/rail condition shall be used for conducting simulations as required by this standard:

- Constant coefficient of friction equal to 0.5 between the wheel and rail.

2.5 Operational parameters

All simulation scenarios shall be conducted at constant speeds as identified in **Table 2**. Tractive and/or braking forces, and/or in-train forces (buff/draft), may be included based on an agreement between the railroad and the carbuilder.

2.6 Simulation requirements

Simulations shall be performed based on the simulation matrix defined in **Table 2** and as defined in sections 2.2 (track), 2.3 (vehicle), 2.4 (wheel/rail interface) and 2.5 (operational parameters). Because these simulations consider a track perturbation in a curve, the simulations should be of sufficient length such that the track perturbation is encountered only after the model has settled to steady-state curving equilibrium.

TABLE 2
Simulation Requirements

Suspension Condition	Load Condition	Speed	Warp Lengths (λ/2), with Initial Warp Amplitude (A) of 3 in. (twice the value of A/2 as shown in Figure 1)			
Nominal	AW0	5 mph	10 ft	20 ft	40 ft	62 ft
		10 mph	10 ft	20 ft	40 ft	62 ft
		15 mph	10 ft	20 ft	40 ft	62 ft
		20 mph	10 ft	20 ft	40 ft	62 ft
	AW3 (fully loaded)	5 mph	10 ft	20 ft	40 ft	62 ft
		10 mph	10 ft	20 ft	40 ft	62 ft
		15 mph	10 ft	20 ft	40 ft	62 ft
		20 mph	10 ft	20 ft	40 ft	62 ft
	Worst case if applicable	Carbuilder to determine if there is a worst-case loading condition between AW0 and AW3 (fully loaded)				
		Matrix of worst-case simulations should be done to satisfaction of railroad and carbuilder				
Deflated air springs, if applicable	AW0	5 mph	10 ft	20 ft	40 ft	62 ft
		10 mph	10 ft	20 ft	40 ft	62 ft
		15 mph	10 ft	20 ft	40 ft	62 ft

Vehicle response is to be evaluated based on the predicted worst-case single wheel L/V ratio. Worst-case response typically occurs at the leading axle outside-rail wheel, but the simulations should not make this assumption. Analysis of the predicted results is to be per the derailment wheel/rail force safety criteria defined in 49 CFR 213.333. Reporting of the safe perturbation amplitude should be based on the single-wheel L/V ratio, as well as any values that are exceeded for the other criteria.

Should the worst-case single wheel L/V ratio for any one simulation case exceed the limit value, and the option of modifying the suspension design is not available, that simulation case shall be repeated with the track twist amplitude reduced by ⅛ in. This process of incrementally reducing the track twist amplitude shall be repeated until a predicted worst-case single-wheel L/V ratio within the limit value is obtained. For each simulation case, the final result shall clearly identify the track twist amplitude, worst-case single wheel L/V ratio, and any other derailment safety indicators exceeding their respective limit values.

2.6.1 Criteria

Performance shall be evaluated using the following criteria from 49 CFR 213.333:

- single wheel L/V
- truck side L/V
- single wheel vertical load ratio (V_{min})
- net axle lateral (NAL) L/V

2.7 Validations

To demonstrate validity of the simulation model used for these analyses, comparison with results of physical tests must be made to demonstrate the correctness of the model formulation, vehicle input data, and the simulation calculations. At a minimum, the following comparisons for model validation are required:

1. Provide test data of the individual suspension components to justify the characteristics used in the model:
    a. Stiffnesses and damping (vertical, lateral, longitudinal, yaw, etc.) as appropriate for the suspension design.
    b. Non-linearities (such as increasing stiffness of a rubber bushing the more it is compressed, stops, etc.) should be included as appropriate.

2. Provide test data for mass and center of gravity height of major assemblies (carbody, truck frame and components, wheelsets, etc.).

3. Provide a comparison between test data and simulations of the following quasi-static tests:
    a. APTA PR-M-S-014-06, latest revision, “Wheel Load Equalization.”
    b. Static Lean tests performed to meet the requirements of APTA PR-M-RP-009-98, latest revision. Please note as the safety advisory (FRA 2013-02) recommends a determination that the suspension systems control static wheel-load distribution when the equipment is stationary on perfectly level track such that the lightest wheel load deviates by no more than 5 percent from the nominal wheel load.
    c. If utilizing structural flexibility of the carbody to meet the requirements of the standard, as described in Section 2.3, a full car end-to-end twist/load equalization test is required. This can be accomplished by raising both wheels on one side of a truck at diagonally opposite corners (i.e., four wheels) of the car by 1.5 in. or by raising both wheels on one side of one truck by at least 3 in., while all other wheels on the same truck and all wheels of the second truck remain level. In either method, wheels shall be raised in increments of 0.5 in. to reach the maximum raise. An alternative test method may be proposed for non-conventional designs, for example articulated trainsets.

   d. Comparisons to include tables of results for the loads on all wheels measured as described in a. through c. above, and any additional measurements as agreed to between the railroad and carbuilder such as primary and secondary suspension deflections.

4. Provide a comparison between test data and simulations to validate the lateral and yaw characteristics as agreed to between the railroad and the carbuilder. Acceptable methods include:
   a. Quasi-static truck rotation tests performed for an entire vehicle:
      - For trucks with side bearings and/or center plates, the comparison needs to demonstrate that yaw resistance output from the friction model is a reasonable match to the test data for the full range of truck rotation.
      - For trucks with shearing springs/airbags, the comparison needs to demonstrate that the effective yaw stiffness due to shearing is a reasonable match to the test data for the full range of truck rotation.
      - If the model predicts variability in rotation resistance to rate of rotation (yaw), the test shall be designed to assess such sensitivity.
   b. On-track testing
      - Tests conducted on a representative curve (including entry and exit spirals) with a radius of curvature of at least 6 deg., or the maximum radius of curvature on the operating railroad if less than 6 deg.
      - Measurements may be done using instrumented wheelsets on one truck or by instrumenting the test curve to measure vertical and lateral forces.
      - The test shall be designed to assess any sensitivity of rotation (yaw) resistance to speed.
      - Comparisons should be conducted between the model predictions using measured track geometry and the measurements from the test site.

2.8 Analysis and reporting

The carbuilder shall perform analyses that assess the vehicle performance according to the simulation requirements identified in Section 2.6. To reduce the risk of wheel climb derailment, vehicles should be designed to meet vehicle track interaction (VTI) performance criteria identified in Section 2.6.1 for the maximum allowable warp amplitude of 3 in. for each wavelength.

A report shall provide the following:

- Detailed description of track, vehicle and truck suspension, reflecting elements mentioned in sections 2.1 through 2.5. Identify wheel profile including flange angle, rail profile and limiting performance criteria required by Section 2.6.1.
- Compliance matrix detailing and confirming simulation track/vehicle parameters, and scenarios that have been analyzed.
- Single-wheel L/V results for all flanging wheels, expressed as L/V or percent of limit (not pass/fail), shall be provided for the maximum amplitude of 3 in. for each wavelength and speed condition analyzed. Should any predicted wheel L/V value exceed the VTI safety criteria for the maximum allowable warp amplitude of 3 in., the report shall provide tables and/or trend plots that clearly indicate the VTI safety limit and the results of additional analysis conducted to determine the track warp amplitude for each wavelength that the vehicle can safely negotiate.
- The worst-case values of all the other Section 2.6.1 performance criteria shall be reported in a table along with the simulation condition(s) and location of wheel/axle on the vehicle for which they occurred. If any value exceeds the limiting value for that performance measure, then the results for that particular criterion shall be provided in tables and/or trend plots that clearly indicate the VTI

safety limit and identify the change in that performance measure as a function of speed and track warp (amplitude and wavelength) conditions.

2.9 Application recommendations

Results from all simulations should be reported to the railroad, clearly defining any limiting track geometry or speed restrictions required to safely operate the equipment in low-speed curving scenarios, with inflated or deflated air springs (for vehicles fitted with air springs).

Based on review of the results with the carbuilder, including potential suspension changes, the railroad at its discretion shall define any limiting conditions for track geometry and maintenance standards, and/or operating instructions to ensure safe operation of the equipment under evaluation. The railroad shall maintain this report as long as the vehicles are owned and it shall be provided to any other railroad or agency for shipping, lease or resale purposes.

Related APTA standards

APTA PR-M-S-015-06, Latest revision, "Wheel Flange Angle for Passenger Railroad Rolling Stock"
APTA PR-M-S-014-06, Latest revision, "Wheel Load Equalization for Passenger Railroad Rolling Stock"
APTA PR-M-RP-009-98, Latest revision, "Truck Design"

References

Where applicable, this standard shall be used in conjunction with the following publications:

49 CFR 213 Code of Federal Regulations, Track Safety Standards

49 CFR 238 Code of Federal Regulations, Passenger Equipment Safety Standards

FRA Safety Advisory 2013-02, Low-Speed, Wheel-Climb Derailments of Passenger Equipment with "Stiff" Suspension Systems, Federal Register Vol. 78, No. 50, March 14, 2013

Definitions

AW0 load: Ready-to-run car weight without any passenger loading as per definition of the railroad.

AW3 load: Car weight with maximum number of passengers both seated and standing as per definition of the railroad.

body of a curve: The portion of a curve that has a constant curvature.

cant: Angle relative to the horizontal plane. For individual rails it refers to the base of the rail. For track it refers to the track superelevation as measured across the top of the two rails.

cant deficiency: The amount by which superelevation must be increased to produce equilibrium. Cant deficiency occurs when a train travels around a curve at a speed higher than the equilibrium speed.

cant excess: The amount by which superelevation must be decreased to produce equilibrium. Cant excess occurs when a train travels around a curve at a speed lower than the equilibrium speed.

coefficient of friction: The ratio of the magnitude of the maximum tangential force acting on a surface due to friction to the magnitude of the normal force on that surface.

cross-level: The vertical distance between the left and right rail.

degree of curvature: The central angle of an arc subtended by a 100-ft chord.

equilibrium speed: The operational speed in a superelevated curve in which the centrifugal forces acting on a vehicle are perfectly opposed by the component of the gravitational force in the lateral direction (parallel to the plane of the running rails).

net axle lateral force L/V ratio: The net axle lateral force, exerted by an axle on the track, divided by the static nominal vertical load exerted by that axle on the track. dynamic static

single-wheel L/V ratio: The ratio of the lateral force that any wheel exerts on an individual rail to the vertical force exerted by the same wheel on the rail.

single-wheel vertical load ratio: The ratio of the vertical wheel load to the static load that the wheel would carry when stationary on level track.

spiral: A length of track of varying curvature (or radius) transitioning between tangent (straight) track and circular curved track. The spiral may also include a corresponding transition in superelevation.

superelevation: The design vertical distance that the outer rail is above the inner rail in a curve.

track twist: The difference in cross-level of any two points at a specific chord length along a segment of track.

track warp: The difference in cross-level of any two points within a specific chord length along a segment of track.

truck-side L/V ratio: The ratio of the lateral forces that the wheels on one side of any truck exert on an individual rail to the vertical forces exerted by the same wheels on that rail.

Abbreviations and acronyms

FRA Federal Railroad Administration
L/V lateral to vertical ratio
NAL net axle lateral
VTI vehicle track interaction

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Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment

Abstract: This standard contains minimum requirements for the physical characteristics, informational content and placement of all emergency signs, markings and instructions for passenger railcar egress/access points. This includes emergency low-location exit path marking (LLEPM) systems for all passenger railcars using passive and/or active means of marking the exit path(s) to safety.

Keywords: emergency exit path, high performance photoluminescent (HPPL), instructions, low-location exit path marking (LLEPM) system, luminescent, markings, photoluminescent (PL), retroreflective, signs

Summary: This standard requires that passenger railcars have interior emergency signage to assist passengers and train crew members in locating and operating emergency exits from the passenger railcar or train. It states requirements for exterior signage to assist emergency responders in locating and operating emergency access points. And it requires that each passenger railcar have an LLEPM system to direct passenger and crew member evacuation, especially during conditions of low visibility such as the presence of smoke.

Scope and purpose: This standard applies to all passenger railcars that operate on the general North American railroad system. It does not apply to rapid transit operations in an urban area that are not connected to the general railroad system of transportation, tourist, scenic, historic or excursion operations, or private railcars. This standard contains minimum requirements and guidance for the design, physical characteristics, informational content and placement of signs, markings, LLEPMs, and instructions for emergency egress and rescue access. This includes signs, LLEPMs and markings used to locate, reach and instruct on the operation of emergency exits and to promote the safe evacuation of passengers and crew members in the event of an emergency. This standard also requires tests to validate the design of the emergency egress and rescue access signs and markings, including LLEPMs. Complementary emergency systems, such as those providing emergency lighting, are covered in separate APTA standards.

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List of Figures and Tables

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Introduction

This introduction is not part of APTA PR-PS-S-006-23, "Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment."

Historically, there have been passenger railcar accidents and incidents that have required the emergency evacuation of passengers and/or train crew members. Review of passenger rail accidents involving passenger and train crew emergency evacuation has indicated that, in certain cases, both passengers and emergency responders lacked sufficient information necessary for expedient emergency egress and access because of the absence of clear markings and instructions. The lack of adequate signage in conjunction with lighting system failures and/or low levels of illumination during conditions of darkness when these accidents occurred were cited as a cause for confusion and as a contributing factor to the injuries and casualties that resulted.

To address these concerns, the National Transportation Safety Board (NTSB) made the following recommendations to the Federal Railroad Administration (FRA), after investigation of a 1996 passenger train accident:

> Issue interim standards for the use of luminescent material, retroreflective material, or both to mark all interior and exterior emergency exits in all passenger cars as soon as possible and incorporate the interim standards into minimum car standards (FRA R-97-16), and
>
> Require all passenger cars to contain reliable emergency lighting fixtures that are each fitted with a self-contained independent power source and incorporate the requirements into minimum passenger car safety standards (R-97-17).

In 1998, FRA issued passenger rail equipment regulations that require that the interior location of each door intended for emergency egress be lighted or conspicuously marked by luminescent material and that the interior location of emergency exit windows be conspicuously marked by luminescent material. Instructions for their use are also required at or near such door exits and windows. These regulations also require that doors and windows intended for rescue access be marked with retroreflective material on the exterior and have operational instructions posted. The FRA issued regulations in 1999 that require emergency lighting for new equipment.

Originally, three APTA standards were created to provide guidance for these regulations. Two of the standards (APTA SS-PS-002-98, "Emergency Signage for Egress/Access of Passenger Rail Equipment," and APTA SS-PS-004-99, "Low-Location Exit Path Marking") have been combined into this standard.

An effective systems approach uses this standard, as well as APTA PR-E-S-013-99, “Emergency Lighting System Design for Passenger Cars,” to provide a means for passengers and train crew members to locate, reach and operate emergency exits and rescue access points to facilitate their safe evacuation in an emergency. Each railroad and car builder should carefully consider the options available to meet emergency evacuation requirements presented in these two standards.

This standard describes the requirements for emergency signs and markings such as LLEPMs on passenger railroad rolling stock for the purposes of emergency egress and emergency access. It applies to all:

1. Railroads that operate intercity or commuter passenger train service on the general railroad system of transportation; and
2. Railroads that provide commuter or other short-haul rail passenger train service in a metropolitan or suburban area, including public authorities operating passenger train service.

This standard may not apply to:

1. Rapid transit operations in an urban area that are not connected to the general railroad system of transportation;
2. Tourist, scenic, historic or excursion operations, whether on or off the general railroad system of transportation;
3. Operation of private cars, including business/office cars and circus trains; or
4. Railroads that operate only on track inside an installation that is not part of the general railroad system of transportation.

Each railroad has the responsibility to ensure that the design, installation and maintenance of the emergency egress/access signage and low-location exit path markings is compatible with its internal safety policies of emergency evacuation, while complying with the performance criteria specified in this standard. Railroads and car builders should carefully consider the options available to meet emergency evacuation requirements presented in the aforementioned standard.

Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment

1. General system requirements

Emergency signs/markings designated for emergency egress/access shall be designed to provide evacuation guidance for passengers and train crew members and rescue access guidance for emergency responders. The railroad shall review the adequacy of emergency egress/access signs and markings as part of the railroad's system safety program plan.

Included among these emergency signs and markings shall be a low-location exit path marking (LLEPM) system. This LLEPM system shall be designed to identify the location of exits and the exit path to be used to reach such exits by passengers and train crew members under conditions of darkness when normal and emergency sources of illumination are obscured by smoke or are inoperative.

1.1 Visual identity and recognition

Emergency egress signage, markings, and LLEPM systems shall enable passengers and train crew members to make positive identification of emergency exits. Each interior sign/marking/LLEPM shall be conspicuous (i.e., clearly recognizable/distinguishable) or become conspicuous immediately and automatically upon loss of power for normal lighting and shall remain conspicuous under the minimum general emergency light illumination levels as specified in APTA-PR-E-S-013-99, "Emergency Lighting System Design for Passenger Cars," as well as under total darkness should the emergency lighting systems fail. All emergency exit, rescue access and LLEPM signage/marking systems shall be designed and installed with consideration for useful field of view (UFOV) to enable passengers, train crew members and rescue responders to make positive visual identification of the exit path, door exits and rescue access without undue delay or confusion. The location of the signs, directional arrow(s) or wording shall guide passengers and train crew members to and along the emergency exit route (see Section 2.1).

All interior emergency signs, markings and LLEPMs shall operate independently of the car's normal and emergency lighting systems for a minimum of 90 minutes (except as noted in Appendix G) after loss of all power for normal lighting.

As per 49 CFR § 239.101(a)(7)(ii), Passenger Awareness Program Activities, each railroad shall conspicuously and legibly post emergency instructions inside all passenger cars (e.g., on car bulkhead signs, seatback decals, or seat cards). Among the ways to fulfill this requirement is the posting of exit orientation signs (for examples of exit orientation signs, see Appendix I.1) inside the car.

1.1.1 LLEPMs

The LLEPM system shall be conspicuous within a volume that includes the entire area of the floor, and which extends upward to a horizontal plane at 4 ft (1.22 m), also known as low location.

1.1.2 Emergency exit signage

All emergency exit and rescue access signage/marking systems shall contain brief and quickly understandable information. Signs/markings and instructions shall use, to the extent practical, commonly recognized/used information symbols, icons, graphics and pictograms, as well as standardized color, contrast, content and placement. Each interior emergency exit sign and emergency exit locator sign shall be visible within a UFOV from a minimum distance of 5 ft (1.52 m) and shall remain conspicuous under the minimum general emergency light illumination levels as specified in APTA PR-E-S-013-99, "Emergency Lighting System Design for Passenger Cars." An emergency exit locator sign shall be located in close proximity of each emergency exit and shall work in conjunction with the emergency exit sign, except as noted in Sections 2.1.4.1 and 2.1.4.2.

> **NOTE:** HPPL signs/markings should not be installed in shadowed locations, to the extent practicable. HPPL material is not meant to be exposed to the weather.

1.1.3 Rescue signage

Each emergency rescue access sign/marking shall be conspicuous on the exterior of the car (see Section 3). Rescue access signage/marking systems shall enable emergency responders to make positive identification of rescue access points without undue hesitation, delay or confusion.

1.2 Multilingual signs

At a minimum, any words included in emergency exit/rescue access signage shall be in English. However, when system-specific determinations are made or are otherwise mandated by local, municipal, state or other regulations, signage/instructions shall be written in designated languages in addition to English.

2. Design requirements

Emergency exit and evacuation information systems on the interior of the car shall, at a minimum, include the following:

- LLEPM markings/delineators indicating a path from all aisle seating and compartment locations, including the lavatory, in the passenger railcar to all the car's door exits (see Section 2.1.1)
- internal door exit locator signs/markings, if necessary (see Section 2.1.2)
- an internal exit sign at each door exit, visible from a low location (i.e., extending from the floor upward to 4 ft [1.22 m] and a horizontal distance of 6 ft [1.93 m] from the exit along the exit path) (see Section 2.1.3.1)
- LLEPM markings along the perimeter of the door or doorframe visible from a low location (i.e., extending from the floor upward to 4 ft [1.22 m], and a horizontal distance of 6 ft [1.93 m] from the exit along the exit path) (see Section 2.1.3.4)
- LLEPM markings on or around the door's operating handle (see Section 2.1.3.5)
- Emergency window exit signs / marking and instructions see Section 2.1.4).

2.1 Location

2.1.1 Exit path

The requirements in this section apply to LLEPMs and systems and electrical and HPPL components thereof, whether installed on walls, floors, seat assemblies or stairs.

The location of the exit path shall be marked using either electrically powered (active) marking/delineators or light fixtures, or HPPL (passive) marking/delineators, or a combination of these two systems.

The marking/delineator components shall be positioned so as to identify an exit path to all door exits that is clearly visible and easily recognizable from any seat or compartment in the car, when normal lighting and emergency lighting are unavailable in conditions of darkness and/or smoke.

The marking/delineator components shall be located on the floor or no higher than 18 in. (45.7 cm) on the seat assembly, or walls/partitions of aisles, passageways or stairways, above the plane of the floor or the nearest stair tread.

The LLEPM system components shall be properly protected to perform in their intended environment for the expected life of the components.

Changes in the direction of the exit path shall be indicated by the LLEPM. This indication must be placed within 4 in. (10.2 cm) of the change in direction of the exit path.

2.1.1.1 Electrically powered (active) systems

Gaps in strip marking/delineation segments/light fixtures shall be no more than 36 in. (91.4 cm) in length, to the extent practicable, provided that a clearly visible and recognizable path to the door exit(s) is maintained.

A. Aisles and passageways

The marking/delineator strip material shall be applied along the floor either as a continuous or intermittent strip, or upon seat assembly on one or both sides of the aisle/passageway.

If light fixtures mounted on a partition or seat assembly are used to delineate the path, then these shall be applied on one or both sides of the aisle/passageway.

A single step in an aisle or passageway that is not part of a multi-step stairway can be treated as part of the aisle for the purposes of this standard.

B. Interior stairways

The marking/delineator material shall be either a continuous strip applied along the walls/partitions of at least one side of the interior stairs, or intermittent strips applied to the riser and/or tread of each step.

When the marking/delineator material is applied to the stairway walls/partitions, it shall be applied as a continuous strip, to the extent practicable extending from the lowest to the highest step.

When the marking/delineator material is applied to the stairway treads, it shall, to the extent practicable, extend across the full width of each tread near the step nosing.

One or more wall-mounted light fixtures shall be installed on at least one side of the interior stairway to illuminate each step, from the lowest to the highest step.

2.1.1.2 HPPL (passive) systems

The width of each marking/delineator strip for aisles, passageways and interior stairways shall not be less than 1 in. (2.54 cm) and shall be applied either as a continuous or intermittent strip.

As an alternative, intermittently placed discs of not less than 1.25 in. (3.18 cm) in diameter may also be used. Strips with fully radiused ends are permitted, so long as they comply with the minimum 1 in. (2.54 cm) width.

If intermittent strips or discs are used, then they shall be placed on both sides of the aisle, passageway or stairway; on the floor or no higher than 18 in. (45.7 cm) above the floor; where practicable, any gaps on either side of the aisle, passageway or stairway shall be staggered.

Examples of the alternative LLEPM configuration can be found in Appendix I.5.

A. Aisles and passageways

HPPL marking/delineator material shall be applied continuously on the floor or no higher than 18 in. (45.7 cm) above the floor, to at least one side or down the middle of the aisle/passageway, or intermittently on both sides of the aisle/passageway, to provide a conspicuous delineation of the exit path to a person standing in the aisle/passageway.

A single step in an aisle or passageway that is not part of a multi-step stairway can be treated as part of the aisle for the purposes of this standard.

The width of marking/delineator strips may consist of multiple parallel strips (multi-strip), as long as the sum of the widths of the multiple strips is equal to or exceeds the 1 in. (2.54 cm) wide strip, and the light output (luminous intensity) per unit length of the multiple strips is equal to or exceeds that of the single 1 in. (2.54 cm) wide strip marking placement.

Intermittent marking/delineator strips shall total a minimum of 6 in. (15.2 cm) in length for every 42 in. (107 cm) segment of exit path. An example utilizing oblong discs can be found in Appendix I.3. Oblong discs shall not have a width less than 1 in.

Discs shall be arranged in a distinctive, recurrent pattern. The sum of the diameters of intermittently placed discs shall total a minimum of 6 in. (15.2 cm) for every 42 in. (107 cm) segment of exit path. Discs shall not have a diameter less than 1 in.

For grandfathered three-clustered disc configurations, see Appendix G.2.2.

B. Interior stairways

In all interior stairways, HPPL marking/delineator material shall be applied, either as a continuous strip applied on the walls of both sides of the stairs or as intermittent strips applied to the riser or tread of each step.

If the HPPL marking/delineator material is applied to the interior stairway walls, then the marking shall be applied as a continuous strip, to the extent practicable, extending from the lowest to the highest step.

If the HPPL marking/delineator material is applied to the stairway treads, then a strip of material at least 1 in. (2.5 cm) wide shall extend, to the extent practicable, across the full width of each tread near the step nosing.

Alternative configurations shall match any of the example configurations provided in Appendix I.5 or shall provide a clear and conspicuous visual delineation of the tread, riser, tread nose and edges of the stairway from the top and bottom landing, and all locations on the stairway.

2.1.2 Door exit locator signs/markings

If a door exit is not within sight of any seat or standee location (e.g., visibly blocked by a bulkhead or divider), then one or more door locator signs shall be provided to identify the location of door exits.

The locator sign(s) shall consist of brief text, graphic arrows or symbols placed in conspicuous areas to direct passengers toward the nearest door that can be used for emergency egress. The conspicuous areas may include the following:

- bulkheads
- dividers
- seat frames/pockets
- luggage racks
- ceilings

2.1.3 Door exits and rescue access doors

2.1.3.1 Door-mounted signs

Each vestibule door, end-frame door and side door leading to the exterior that is intended for emergency egress shall be clearly identified with, at a minimum, two interior exit signs/markings:

- An exit sign shall be located on the door or door glazing, or in the immediate proximity. The center of the sign shall be located on or immediately adjacent to the upper half of the door and shall be conspicuous (see Sections 2.2, 2.3, 2.4 and 2.5), containing the wording "EXIT," "EMERGENCY EXIT," or other similar wording in capital letters.
- An exit sign shall be located on or immediately adjacent to each door and placed between 6 and 18 in. (15.2 and 30.5 cm) above the floor. If traps are present, the traps are considered closed for the sake of this requirement.

2.1.3.2 Removable panels

For passenger cars ordered on or after Jan. 28, 2014, or placed in service for the first time on or after Jan. 29, 2018, removable panels or windows are required on doors as per 49 CFR § 238.112 (f)(2).

The openings around removable panels or windows shall have a 1 in. wide HPPL border outlining the outer edges of the panel on the opening surrounding the inside and outside of the door. Windows shall be marked as per Section 2.1.4.2.

Instructional signage on or directly above the inner and outer faces of the panel or window shall be made of HPPL material. Identification and operating instructions to remove the panel or window in case of an emergency shall be provided.

> **NOTE:** It is permissible to place an exit sign as required in the second bullet of Section 2.1.3.1 on the removeable panel. It is understood that once the removeable panel or window has been removed, there need not be an exit sign on the door at a height between 6 and 18 in. (15.2 and 30.5 cm) above the floor.

2.1.3.3 Routinely locked doors

When a door designated as an exit is locked (such as an end-frame door at the end of the train), additional measures shall be taken to provide emergency opening instructions for the door exit or to direct passengers to an alternative door exit and/or emergency window exit. These measures may include the following:

- PA announcements
- safety seatback cards
- permanent signage or markings

2.1.3.3.1 Failure enroute

When a door fails enroute and is rendered disabled as an emergency exit, additional measures shall be taken to direct passengers to an alternative door exit and/or emergency window exit, as required by 49 CFR § 238.305 (c)(10).

2.1.3.4 Door exit delineators/markings

Each door exit shall be clearly marked/delineated with HPPL marking/delineator material placed in close proximity to or on the door exit. A minimum of 1 in. (2.54 cm) wide strips shall be applied to the extent practicable to the left and right sides of the interior of each door exit or doorframe and shall extend from the floor to a minimum height of 12 in. (30.5 cm) above the floor. If unable to extend HPPL material from the floor directly, the marking/delineator shall start at the lowest location possible (within 6 in. [15.2 cm] of the floor) and extend at least 12 in. (30.5 cm) vertically from that point. If this is not possible, then sufficient HPPL material shall be placed on the door, doorframe or adjoining wall between the floor and an 18 in. (45.7 cm) vertical limit, so that the total area is at least 12 sq in. (77 cm^2) on both the left and right sides. The markings need not be visible when the door is open. Additional material placed above 18 in. off the floor is permitted but does not count toward this requirement.

The above also applies to the interior faces of any restroom doors for restrooms that are ADA compliant.

2.1.3.5 Door exit control locator signs/markings and instructions

Each exit door handle, latch or operating button shall be marked with HPPL material in the form of outline striping that is no less than 1 in. (2.54 cm) wide to the extent practicable (see Appendix I for applications) around the perimeter of or behind the opening device with the total surface area being no less than 16 sq in. (103 cm^2) to the extent practicable. For grandfathered door markings consisting of less than 16 sq in. of HPPL material, see Appendix G.2.1.

In addition, each power door equipped with a separate manual override device intended for emergency egress shall be marked with a sign/marking containing the words “Emergency Door Control,” “Manual Door Control,” or other similar wording/icons. These signs/markings shall be placed at the manual door control or at an appropriate location in its immediate proximity.

If the manual override device is not located in close proximity to the door handle, latch or operating button, then a door control locator sign shall be posted. The manual door control locator sign(s)/marking(s) shall consist of brief text, graphic arrows or symbols to direct passengers and crew members from the door control to the location of the manual door override.

If the method for opening a door intended for exit is not obvious, then operating instructions shall be posted at that door’s control or in its immediate vicinity.

Operating instructions shall be posted at or near each manual override device for a door intended for emergency egress.

2.1.4 Emergency window exits

2.1.4.1 Window exit locator signs/markings

Emergency window exit locator signs/markings directing passengers and crew members to the nearest emergency window exit location(s) shall be provided. The signage/marking shall use the words "EMERGENCY EXIT" or similar wording. This signage/marking may take the form of:

- signage/marking on walls;
- signage/markings on light fixtures located above the emergency window exit; and/or
- signage/markings located on the ceiling, window or seat frames.

One sign/marking may serve more than one emergency window exit if the sign/marking can readily identify each such exit. If all the side windows installed in the passenger compartment of the railcar can be used for emergency egress, then locator signs are not required.

An emergency window exit sign (see Section 2.1.4.2) may serve as a locator sign if it meets the minimum requirements for a locator sign. For examples, see Appendix I.2. If an additional locator sign is used when the emergency exit sign meets the requirements of a locator sign, the additional sign need not meet the requirements of this standard.

2.1.4.2 Exit signs/markings and instructions

Each interior emergency window exit shall be identified with a sign/marking located on or adjacent to each such window.

In addition, instructions, including pictorial diagrams, for exiting the window shall be posted on or adjacent to each such window.

Each emergency window exit equipped with a pull handle shall be identified with an "EMERGENCY EXIT PULL HANDLE" marking; either as an integral part of the handle marking, or with instructions/illustrations applied as a decal in the immediate vicinity, or a combination of these.

Locations that are space-limited, such as the emergency window pull handle, as well as supplemental operating instructions, shall have the characters as large as feasible for the allotted space.

A. Breakable emergency exit windows

If approved by the FRA, breakable emergency exit windows that require a readily accessible tool appropriate to break the glass shall have a pictogram type decal prominently displayed next to the tool/window location indicating the intended use of the tool. Each breakable window that is intended as an emergency exit shall have a dedicated removal device.

The location of the tool shall be outlined with a one-inch HPPL strip or equivalent.

2.2 Letter and sign size

2.2.1 Letter size

> **NOTE:** Requirements provided herein do not apply to instructional signage/marking unless otherwise noted below.

The letter characters on emergency exit signs and markings and emergency exit locator signs intended to be read by the general public shall have the following minimum character height using uppercase letters:

- 1 in. (2.54 cm) on emergency window exit signs and locator signs
- 1½ in. (3.81 cm) on door exit signs and locator signs

In addition, the characters shall have the following characteristics:

- a width-to-height ratio between 3:5 and 1:1;
- a stroke-to-width ratio between 1:4 and 1:6 (i.e., the width of the lines that are combined to produce a letter); and
- spacing between letters of a minimum of one-sixteenth the height of the uppercase letters.

NOTE: Raised letter characters may be utilized.

2.2.2 Sign size

A minimum sign area of 16 sq in. (103 cm^2) is required for all end and side door exit signs installed except as noted in Appendix G.3.1.

2.3 Color and contrast

Lettering and pictograms used on interior emergency exit signage/marking shall be designed to achieve a luminance contrast ratio of not less than 0.5, as measured by a color-corrected photometer.

2.4 Illuminance/luminance criteria

LLEPM and sign/marking component illumination or luminance levels, as applicable, shall be verified in accordance with Section 4 and tested, maintained and repaired in accordance with Section 6.

HPPL material shall be installed in locations and orientations that provide exposure to adequate charging light.

NOTE: Dual-mode LLEPM system components may be used to increase visibility.

Additional measures for addressing extenuating circumstances are described below and in Appendix B.

2.4.1 Electrically powered systems

The light sources used to comply with the criteria required in this section shall be electrically powered (e.g., incandescent, fluorescent, EL or LED).

2.4.1.1 Illuminance/luminous intensity

For signs/markings with exposed LEDs that spell out “EXIT,” each LED shall have a minimum peak intensity of 35 mcd, except as noted in Appendix G.3.2.

Where light fixtures are mounted on the walls or seat pedestals/frames or components, each light fixture shall provide an average illumination value of at least 0.1 fc, measured on the surface of the floor or step averaged at intervals of 30 in. (76.2 cm) or less along the center of the aisle, passageway or stairs.

Each point source/strip shall comply with the following criteria:

- **Incandescent:** Miniature lamps not less than 150 mcd mean spherical intensity with a maximum spacing of 4 in. (10.2 cm) between lamps
- **LED:** Minimum peak intensity of 35 mcd with a maximum spacing between lamps of 12 in. (30.5 cm)

For additional information regarding charging light, see Appendix B.2.

2.4.1.2 Luminance

The average luminance value of the electrically illuminated marking/delineator strip or sign/marking shall be at least 1000 mcd/m^2, as measured on the surface marking, delineator or sign.

> **NOTE:** Most electroluminescent signs have an initial luminance of more than 20,000 mcd/m^2, but they may show substantial luminance degradation (more than 80%) over their service lives. Service life estimates range from 30,000 hours to 100,000 hours (7 to 20 years) for stationary equipment.

2.4.2 Passive systems

2.4.2.1 Materials

Internal signs, markings and delineators constructed of HPPL material, including LLEPM components, shall be capable of providing a minimum luminance level of 7.5 mcd/m^2 for a duration of 90 minutes after the charging light has ceased, except as noted in Appendix G.

2.4.2.2 Charging light

The illuminance levels required to provide sufficient charging light vary according to the type of light source used.

For additional information regarding charging light, see Appendix B.

2.4.3 Dual mode systems

Dual-mode systems composed of active and passive components shall be designed so the HPPL material is adequately charged by an active light source in order to comply with the minimum luminance criterion of 7.5 mcd/m^2 for a duration of 90 minutes after activation lighting has been removed or ceased operating. For additional information regarding charging light, see Appendix B.

2.5 Component materials

Interior emergency exit signs/markings complying with Sections 2.2 and 2.3 shall be constructed of active electrically powered light sources, passive HPPL material, dual-mode systems or a combination, as specified in this section.

2.5.1 Vestibule, end-frame and side doors

Emergency exit signs/markings shall identify the location of all vestibule, end-frame and side doors leading to the exterior of the car and intended for emergency egress using:

- HPPL material, including dual mode; or
- electrically powered fixtures with an independent power source, located in or within each half car length, that can power the signs/markings for at least 90 minutes after power for normal lighting ceases.

For electrically powered illuminated signs that use a battery as an independent power source, an automatic self-diagnostic module shall be connected to such a power source and installed where its status indicator can be readily observed during the daily inspection (see Appendix D).

For grandfathered vestibule, end-frame and side door signs/markings, see Appendix G.2.3.

2.5.1.1 Additional requirements to mark side door exit locations without independently powered emergency lighting

Each side door opening intended for emergency egress leading to the exterior of the car shall be marked with a minimum of 144 sq in. (929 cm^2) of HPPL material placed no higher than 18 in. (45.7 cm) off the floor, with its lowest point no higher than 6 in. (15.2 cm) off the floor.

> **NOTE:** The marking may be composed of one or more panels placed either on the door and/or in its immediate vicinity. A door with two leaves that open for emergency egress is considered a single door opening. Therefore, 144 sq in. (929 cm^2) of HPPL material is sufficient for that door opening.
>
> To provide some illumination at the floor for passengers and crew members as they exit, to the extent practical, the material should not be placed on a door leaf that is intended to open for emergency egress or on the part of a wall or partition that would be covered by a trap door in any position (e.g., sliding doors).

Signs and markings used to comply with the LLEPM requirements may be counted toward this requirement to the extent that they meet the criteria noted above (e.g., HPPL door delineators required to meet the LLEPM requirements that are installed on the door 18 in. [45.7 cm] off the floor would count as 36 sq in. [232 cm^2] of the 144 sq in. [929 cm^2]).

3. Design requirements, exterior

Rescue access information systems on the exterior of the car shall, at a minimum, include the following:

- external rescue access door signs/markings (see Section 3.1.1.1.)
- rescue access door control locator signs/markings and instructions (see Section 3.1.1.2)
- external rescue access window signs/markings and instructions (see Section 3.1.2)
- external rescue access door emergency release mechanism locater signs/markings and instructions (see Section 3.1.3)

3.1 Location

3.1.1 Rescue access doors

3.1.1.1 Signs/markings

Each door intended for use by emergency responders for rescue access shall be externally identified with emergency access signs, symbols or other conspicuous marking consisting of retroreflective material that complies with Sections 3.3 and 3.4.

3.1.1.2 Control signs/markings and instructions

Each door intended for use by emergency responders for rescue access shall have operating instructions for opening the door from outside the car placed on the car body within a distance no greater than one and a half times the width of the door leaf from the door opening. If a power door does not function with an integral release mechanism, then the instructions shall indicate the location of the exterior manual door control.

Each power door intended for use by emergency responders for rescue access that has a non-integral release mechanism located away from the door shall have a door control sign/marking placed at the location of this control that provides instructions for emergency operation, either as part of the access sign/marking or as another sign/marking.

Each car equipped with manual doors shall have operating instructions for opening the door from the exterior, either as part of the access sign/marking or as another sign/marking.

All primary identification markings (e.g., emergency door release) shall be made of material consistent with Section 3.4.

3.1.2 Rescue access windows

Each rescue access window shall be identified externally with a unique retroreflective and easily recognizable sign, symbol or other conspicuous marking that complies with Sections 3.3 and 3.4.

Signs, symbols, or markings shall be placed externally at the bottom of each such window, on each window, or adjacent to each window, using arrows where necessary to clearly designate rescue access window locations. Legible and understandable window-access instructions, including any pictogram/instructions for removing the window, shall be posted at or near each rescue access window.

> **NOTE:** An emergency exit window and rescue access window may utilize the same window as long as the window is marked according to Section 2.1.4.1 on the inner face of the window and Section 3.1.2 on the outer face of the window.

3.1.3 Emergency roof access

The location of each emergency access point provided on the roof of a passenger car shall be clearly marked with retroreflective material of contrasting color that complies with Sections 3.3 and 3.4. Legible and understandable instructions shall be posted at or near each such location.

Signs at the access point shall have a total area of no less than 98 sq in. (632.3 cm^2) and shall contain appropriate text and/or icons for the method of access. The wording and icons on the signs shall have the same orientation and shall be entirely within the confines of the retroreflective border identifying the access point.

> **NOTE:** Concise wording and the use of icons where possible is recommended.

If emergency roof access is provided by means of a structural weak point:

- The line along which the roof skin is to be cut shall be clearly shown with retroreflective tape of contrasting color.
- A sign plate with a retroreflective border shall also state (unique to the vehicle and to the particular railroad):
    - “CAUTION: DO NOT USE FLAME CUTTING DEVICES.”
    - “CAUTION: WARN PASSENGERS BEFORE CUTTING. CUT ALONG DASHED LINE TO GAIN ACCESS.” or
    - “ROOF CONSTRUCTION: [state relevant details].”

If emergency roof access is provided by means of a hatch:

- A sign with a retroreflective border, or entirely retroreflective, in either case of a contrasting color, shall be applied to the outside of each hatch. This sign shall, at a minimum, state the following:
  - In large letters: “EMERGENCY ACCESS” or words to that effect.
  - In smaller letters, instructions for opening the hatch.

3.2 Letter size

All external primary identification markings (e.g., emergency door release) shall have letters no less than ⅜ in. in height. All external instructional signs shall have letters no less than 3⁄16 in. in height.

3.3 Color and contrast

Exterior signs/markings shall provide lettering-to-sign-background and sign-to-substrate luminance contrast ratio of not less than 0.5, as measured by a color-corrected photometer.

Characters and their background shall have a non-glare finish. Characters shall contrast with their background, with either light characters on a dark background, or dark characters on a light background.

> **NOTE:** A contrasting border around the outer edge of the sign may also enhance visibility.

3.4 Materials

Exterior emergency rescue access locator signs/markings shall be constructed of retroreflective material that conforms to the specifications for Type I material sheeting, as specified in ASTM D-4956-07 1e, “Standard Specification for Retroreflective Sheeting for Traffic Control.” Retroreflective material shall be compatible with the type of mounting surface.

4. Evaluation measurements and tests

4.1 Interior signs/markings

To verify that emergency signage and LLEPM system component designs comply with the requirements of Section 2.4, railroads shall ensure that a qualification test of the normal lighting is conducted on at least one representative passenger car/area for each signage and LLEPM system layout, in accordance with this section and Appendices C and F.

Before equipment is placed in service for the first time, the first car to have an emergency signage and LLEPM system installed shall be tested, and this test shall be completed prior to the car’s release for operation in revenue service.

The railroads shall confirm that the emergency exit signage and LLEPM system components comply with the minimum required illumination or luminance criteria, as applicable, for the specified duration.

4.1.1 Electrically powered (active) systems

Test reports provided by the manufacturer/supplier with results certified by an independent laboratory shall show that electrically powered components have been photometrically tested as appropriate for the type of light source. These shall show:

- luminance for EL markings; and
- luminous intensity for point sources.

All results must comply with Section 2.4.1.

Railroads shall confirm that the power supply for electrically powered signage and LLEPM components will maintain the operating voltages specified by the sign/marking manufacturer/supplier for at least 90 minutes after the loss of primary power supply, except as noted in Appendix G.

To ensure compliance with Section 2.4.1, measurements of electrically illuminated signs/markings shall be conducted in accordance with Sections 3.2, 3.3, 3.4.1, and 3.4.2 of this document, as well as Table 1 in Section 2.2 of APTA PR-E-S-013-99, Rev. 2, "Emergency Lighting System Design for Passenger Cars."

For information on automatic testing of electrically powered systems, see Appendix D.

4.1.2 HPPL (passive) systems

4.1.2.1 Material luminance

Test reports provided by the manufacturer/supplier with results certified by an independent laboratory shall show that all tested samples of passive HPPL material, as used in the finished component configurations (including any cover or protective coating if used, but not including text or graphics) comply with the minimum luminance criterion of 7.5 mcd/m^2 after 90 minutes, when tested according to the provisions of ASTM E-2073-010 "Standard Test Method for Photopic Luminance of Photoluminescent (Phosphorescent) Markings" (www.astm.org) except as noted in Appendix G.

For more information on independent test laboratories, see Appendix E.

The manufacturer/supplier is required to have a minimum of one batch of material for signs/markings/ delineators of a given type certified. Signs/markings/delineators of the same certified type of material can be sold to multiple customers.

4.1.2.2 Ambient light charge

To confirm that HPPL emergency sign/marking components are installed in locations that receive adequate charging light, illuminance measurements shall be taken. To take the measurement readings, the sensor is placed on the area of the HPPL sign/marking surface location where the light is brightest (or on the floor location as permitted in Appendix G.1.2). The observer records the reading(s) using a data collection form (see Appendix C.4).

The sensor and the readout device of the illuminance meter must be held in a manner so that the sensor is not affected by the observer's shadow. If light diffusers are used on the light fixtures, then the measurements shall be made with the light diffusers in place. This requirement applies to each representative car/area tested.

More information on representative samples can be found in Appendix F.

The charging light shall consist only of that provided by the car's normal lighting system. All natural or other external light shall be excluded. For suggested methods for eliminating extraneous light sources, see Section 3.2 of APTA PR-E-S-013-99, Rev. 2.

If the ambient light cannot be reduced to 0.01 fc, see Appendix B.3.

To take the measurement readings, the sensor is placed on the area of the HPPL sign/marking surface location where the light is brightest (or on the floor location as permitted in Appendix B.3). The observer records the reading(s) using a data collection form (see Appendix C.4).

If light diffusers are used on the light fixtures, then the measurements shall be made with the light diffusers in place.

> **NOTE:** If the ambient (normal charging light) illuminance is less than the required criteria specified (see Section 2.4.2.1), then railroads can take several actions described in Appendix B.2 to increase the charging light levels.

4.1.3 Testing equipment

To ensure accurate illuminance measurements including measurements on vertical surfaces at which the angle of incident light is large, the light meter must be designed to take such measurements and possess all of the following:

- **Basic accuracy:** ±3% of reading ±1 digit or better
- **Low-end sensitivity:** 0.01 fc or better
- **Cosine error:** No more than 6%, measured at 50 deg
- **Color correction:** Correction to CIE photopic curve

For additional HPPL material considerations, see Appendix B. For alternatives to increase charging light output, see Appendix B.2. For additional HPPL material testing technical considerations, see Appendix B.3. For additional details on charging light measurement procedures, see Appendix C.

4.2 Exterior signs/markings

Railroads shall ensure that retroreflective material meets the requirements for Type I sheeting materials, per ASTM D-4956-07.

4.3 Recordkeeping

Railroads shall retain copies of:

- test reports provided by the manufacturer/supplier with results certified by an independent laboratory showing that the illuminance or luminance measurements, as appropriate, on the active area of the signage/marking/delineator component comply with the criteria specified in Section 2.4, as applicable, of this standard (for HPPL systems, see Appendix C);
- railroad-approved illuminance test plan(s) and test results until the next periodic test, or other test specified in Appendix C, is conducted on a representative car/area; and
- test report results that certify that the retroreflective material complies with Type I materials per ASTM D-4956-07.

These reports shall be retained until all cars impacted by the above documents are retired, or are transferred, leased or conveyed to another railroad. A copy of such records shall be provided to the accepting railroads, along with any cars that are transferred, leased or conveyed.

5. Survivability requirements

Signs, markings and delineators, including LLEPMs, shall be conspicuous under all operating conditions, including buildup of dust and dirt as well as discoloration of the HPPL or light diffuser components.

All LLEPMs and emergency signs/markings shall be designed to operate without failure under the conditions typically found in passenger rail equipment, including expected mechanical vibrations (as defined by IEC 61373-1) and shock, as well as comply with electromagnetic interference and other criteria in 49 CFR §§ 238.225, 238.425, and 238.725.

All electrically powered LLEPM and emergency sign/marking components independent power sources in passenger cars shall be designed to operate in all equipment orientations and after the initial shock of a collision or derailment resulting in the following individually applied accelerations:

- **longitudinal:** 8g
- **lateral:** 4g
- **vertical:** 4g

6. Inspection

6.1 Daily inspections

As part of the daily interior and exterior inspections required in 49 CFR §§ 238.303 and 238.305, railroads shall visually inspect all emergency signage and LLEPM system components, and emergency markings/ delineators, except those for roof access, to determine that signs/marking components are present and conspicuous, and that signs and instructions are legible.

The status indication from automatic testing of electrically powered systems (see Appendix D) shall be observed to confirm that a unit is functioning normally.

6.2 Periodic inspections and tests

Railroads shall conduct periodic inspections and tests to verify that all emergency signage and LLEPM system components, including power sources, function as intended. Railroads shall test a representative sample of passenger railcars in accordance with Sections 6.2.1 and 6.2.2. For more detailed information, see Appendix B.3 and Appendices C, D and F.

6.2.1 Electrically powered (active) systems

Railroads shall perform periodic tests to confirm that electrical component(s), including the emergency power source, function as intended and comply with Sections 2.4.1.1 and 2.4.1.2. Tests shall be conducted no less frequently than once every eight years, with the first test conducted no later than eight years after the car was placed in service for the first time.

The tests shall verify the minimum illumination/luminance level and duration of all LLEPM system components. Electrically powered components shall be photometrically tested as appropriate to the type of light source:

- illuminance for internally illuminated signs/markings/delineators; and
- luminance for EL signs/markings/delineators.

If the electrically powered system design does not change, and at the same time components are replaced with like kind, then the periodic testing of an electrically powered system will not require reverification of minimum illumination levels.

Independent power sources using batteries shall be certified by their manufacturers/suppliers to be capable of maintaining operation of the sign/marking components to which they are connected for at least 90 minutes as required by Section 4.1.1.

For electrically powered illuminated interior door exit signs and LLEPM components that use a battery as an independent power source and have an automatic self-diagnostic module, the module shall perform discharge tests. (See Appendix D for additional guidance.)

For electrically powered LLEPM components that use capacitors as independent power sources, a functional test shall be conducted as part of the periodic inspection.

6.2.2 HPPL (passive) systems

Railroads shall also conduct tests specified in this section to verify that all HPPL (passive) interior emergency signage system components receive sufficient illuminance from the charging light to provide the required luminance for the required duration (see Section 4.1.2.1). Charging light shall be photometrically tested as appropriate to the type of light source.

If the normal lighting system of a car type is reconfigured, the illumination levels shall be retested on at least one example of all affected areas.

Railroads shall conduct periodic illuminance tests to confirm that HPPL components receive adequate charging light. These shall occur no less frequently than once every eight years, with the first test conducted no later than eight years after the car was placed in service for the first time, for only the following HPPL components:

- HPPL signs/markings/delineators placed in areas designed or maintained with normal light levels of less than 5 fc
- grandfathered HPPL materials, where the sign/marking/delineator is placed in an area designed or maintained with normal light levels of less than 10 fc

If the HPPL system design or normal lighting system design does not change, and at the same time components are replaced with like kind, then the periodic testing of the HPPL system will not require re-verification of minimum charging illumination levels.

If all of the illuminance levels in the first two randomly selected representative sample cars exceed the minimum required to charge the HPPL components required by this standard by at least a factor of two, then no further testing is required for the cars represented by the sample car tested for the periodic test cycle.

6.3 Defect reporting, repair and recordkeeping

Illegible, broken, damaged, missing or non-functioning components of emergency signage/markings or the LLEPM system, including the normal and emergency power systems, shall be reported and repaired in accordance with railroad procedures that comply with 49 CFR § 238.19 defect reporting procedures.

Recordkeeping shall be in accordance with railroad procedures that comply with 49 CFR § 238.19 recordkeeping procedures.

Related APTA standards

APTA PR-CS-S-012-02, "Passenger Car Door Systems for New and Rebuilt Passenger Cars"
APTA RP-E-RP-007-98, "Storage Batteries and Battery Compartments"
APTA RP-E-RP-012-99, "Normal Lighting System Design for Passenger Rail Equipment"
APTA PR-E-S-013-99, "Emergency Lighting System Design for Passenger Cars"
APTA PR-IM-RP-001-98, "Passenger Rail Equipment Battery System Periodic Inspection and Maintenance"
APTA PR-IM-S-005-98, "Passenger Compartment Periodic Inspection and Maintenance"
APTA PR-IM-S-007-98, "Passenger Car Exterior Periodic Inspection and Maintenance"
APTA PR-IM-S-008-98, "Passenger Car Electrical Periodic Inspection and Maintenance"
APTA PR-IM-S-013-99, "Passenger Car Periodic Inspection and Maintenance"
APTA PR-M-S-018, "Powered Exterior Side Door System Design for New Passenger Cars"
APTA PR-PS-S-001-98, "Passenger Railroad Emergency Communications"
APTA PR-PS-S-003-98, "Emergency Evacuation Units for Passenger Cars"

References

This standard shall be used in conjunction with the applicable sections of the following publications. When the following publications are superseded, the revision shall apply.

American National Standards Institute/American Society for Quality Control, ANSI/ASQC Z1.9-1993, Sampling Procedures and Tables for Inspection by Variables.

American Public Transportation Association:
PR-E-S-013-99, Rev. 2, "Emergency Lighting System Design for Passenger Cars"

ASTM International:
D-4956-07 1e, "Standard Specification for Retroreflective Sheeting for Traffic Control"
E-2073-010, "Standard Test Method for Photopic Luminance of Photoluminescent (Phosphorescent) Markings"

Code of Federal Regulations:
49 CFR § 223, Safety Glazing Standards
49 CFR § 238, Passenger Equipment Safety Standards
49 CFR § 239, Passenger Train Emergency Preparedness

Federal Railroad Administration (FRA):
Emergency Order Number 20, Notices 1 and 2

National Transportation Safety Board Recommendations to Federal Railroad Administration, FRA R-97-16 and R-97-17.

Definitions

active illumination: Illumination generated by electrical energy.

aisle: A path through a vehicle that is not bordered by walls, such as down the center of a coach car that has a row of seats on each side (may include a ramp or single step)

alternative door exit: Exit point (usually a side door) used by passengers and crew to egress from the affected car and/or the train in an emergency if the door exit is locked, unavailable or unsafe.

auxiliary power system: An onboard source of electrical power (e.g., alternator/generator/car battery) typically used under normal operating conditions to supply such functions as lighting, air conditioning, etc.

candela (cd): Unit of luminous intensity in both SI and English measurement systems. One candela is one lumen per steradian (lm/sr). It is almost exactly equal to the obsolete unit called the candle.

car body end door: A door located at the collision posts. A car body end door may be used as an exit when safe to do so or when the train is in motion to enable passengers to relocate to safety in another car.

car body side door: A door in a passenger compartment or vestibule exiting to the exterior of the car; useable after the train has stopped.

color temperature: A numerical descriptor of the hue of a light source. It is expressed in terms of degrees on the Kelvin scale and refers to the temperature of a black-body radiator that produces light of the same hue as the source specified. Low color temperatures correspond to reddish sources, such as candle flames or incandescent lamps. Higher color temperatures are associated with cool-white fluorescent lamps, LEDs, blue sky and several types of new lighting technology.

door exits: The normal (preferred) door exit points used by passengers and crew members to egress from the affected car in an emergency.

dual mode: Using a combination of active (electrically powered) and passive (PL) light sources.

electroluminescence (EL): Luminescence resulting from the application of an alternating electrical current to phosphor.

emergency exit: A door through which an exit path terminates.

emergency exit locator signs: Conspicuous emergency marking/signage used to identify and/or direct passengers to the nearest emergency exit location(s) that meet the pertinent requirements described in Section 2.

emergency window: A window designed for removal from the inside of the vehicle in case evacuation is necessitated.

emergency signage: Textual and graphic messages designed to assist passengers and train crew members in locating and using railcar emergency exits and to assist emergency responders in gaining access to railcars using doors and windows from the exterior.

end-frame door: An end-facing door located between or adjacent to collision posts or similar end-frame structural elements of a passenger car.

exit path: The path or corridor through a railcar that provides the preferred path of evacuation from the car.

exterior side door: A door used as the means of passenger boarding and disembarking from a passenger car and in the event of an emergency after the train has stopped.

externally illuminated: Illuminated by a light source outside the sign, device, legend, marking or path itself (e.g., a non-photoluminescent sign with a light source shining on its surface). This source may be designed to provide dedicated illumination for a specific location or general emergency illumination. Fluorescent lamps, LEDs or occasionally incandescent lamps are typically used.

foot-candle (fc): A unit of illuminance. One foot-candle is one lumen per square foot (lm/sq ft). In the SI system, the units of illuminance are lux (1 fc = 10.76 lux).

head-end power (HEP): A system by which electrical power is provided to railroad vehicles from a central source via a trainline system. The source of power can be a locomotive or a power car (wayside supply from catenary, third rail or trackside can also be transformed into HEP as it passes through the power system). HEP is used under normal operating conditions to provide electrical power to the passenger equipment systems, such as "normal" lighting. In the United States, 480 VAC, 60 Hz, three-phase systems are most common.

high-performance photoluminescent (HPPL) material: A photoluminescent material that is capable of emitting light at a very high rate and for an extended period of time. For this standard, the minimum luminance value for HPPL is 7.5 mcd/m^2, 90 minutes after removal of the charging light source. Unless otherwise permitted by this standard, for rating purposes, the charging light source required is a fluorescent lamp with a color temperature of 4000 to 4500 °K that provides an illuminance of no more than 1 fc for a duration of no more than 60 minutes.

HPPL material (former definition): A material capable of emitting light at a high rate and for an extended period of time. For this standard, the minimum luminance value for HPPL is 7.5 millicandelas per square meter (7.5 mcd/m^2), 90 minutes after removal of the charging light source. Unless otherwise permitted by this standard, for rating purposes, the charging light source is specified as a fluorescent lamp with a color temperature of 4000 to 4500 °K providing an illuminance of no more than 5 fc on the test sample for a duration of no more than 60 minutes.

icon: A sign or representation that stands for an object by virtue of a resemblance or analogy to it.

illuminance: The amount of light (luminous flux) falling on a specific (unit) surface area (e.g., 1 sq ft). English units are foot-candles (fc) or lumens per square foot (lm/sq ft). SI units are lumens per square meter (lm/m^2) or lux (lx) (1 fc = 10.76 lux).

independent power source: A sealed battery or other energy storage device located within the car body designed to power one or more emergency light fixtures or other devices when the normal HEP, main car battery, auxiliary power and/or wayside power are unavailable.

instructional signage: Textual and/or graphic message signs that simply express information and details about how something should be done or operated.

internally illuminated: Illuminated with a light source contained inside the sign, device, marking or legend itself, e.g., a light fixture with the word "EXIT" printed on the diffuser. The light source is typically incandescent, fluorescent, EL or LED.

lighting, emergency: A lighting mode that is available when power for the normal lighting and standby lighting (if equipped) becomes unavailable. The main car battery or one or more independent power sources can be used to supply the power to operate the fixtures that provide emergency lighting.

lighting, normal: A lighting mode that is available when the car is in operation with the normal power system.

low-location: The area of the railcar defined by a volume that includes the entire area of the floor, and which extends upward to a horizontal plane at 4 ft (1.22 m).

luminaire: A device to produce, control and distribute light. A complete unit typically consists of one or more lamps, sockets to hold and protect the lamps, optical devices to direct the light, and circuitry to provide the required electric power to the lamp(s) and/or LEDs. Commonly referred to as a light fixture.

luminance: The amount of light reflected from a unit area or surface, or the amount of light emitted from a surface, e.g., electroluminescent or LED material. English units are foot-lamberts (fl). SI units are candelas per square meter (cd/m^2) (also called "nits") and millicandelas per square meter (mcd/m^2). (1 fl = 3.426 cd/m^2 or 3426 mcd/m^2.)

luminescence: The emission of light other than incandescent, as in phosphorescence or fluorescence by processes that derive energy from essentially nonthermal sources through excitation by radiation.

luminous intensity: The luminous flux per unit solid angle in the direction measured. Expressed in candelas or lumens per steradian.

luminance contrast ratio: The relationship or difference between the object and its immediate background, defined by the following ratio:

$$\frac{L1 - L2}{L1}$$

Where: L1 = luminance of background
L2 = luminance of the object in question (e.g., lettering, pictogram, symbol)

marking/delineator: A visible notice, sign, symbol, line or trace.

passageway: A path through a vehicle that is bordered by walls to allow a passenger or crew member the ability to move from one location to another.

passenger car and/or car: Rail rolling equipment intended to provide transportation for members of the general public. Can be either self-propelled or locomotive hauled and is designed to carry passengers, baggage, mail or express.

passive illumination: Illumination generated without the use of direct electrical energy.

photoluminescent (PL) material: Material having the property of emitting light that continues for a length of time after excitation by visible or invisible light has been removed (i.e., self-illuminating).

pictogram/pictograph: A pictorial sign or symbol.

> **NOTE:** Both words share the same meaning. For the purposes of this standard, the term "pictogram" is used.

representative car: A car that shares relevant characteristics with the cars it represents (i.e., same LLEPM layout and charging light system for passive LLEPM systems, or same light fixtures and power system for electrically powered LLEPM systems).

rescue access window: A window designed for removal by first responders from the exterior of the car.

sign: A display board, poster placard or marking/delineator using text and/or graphics to convey information or direction.

spatial average: The average of all samples taken in the vicinity of a specific location. The area of a spatial average varies. For a stairway, it comprises only the area of the stair step(s). For an aisle, the entire length of the aisle is included.

stairway: A continuous set of steps (not interrupted by a landing).

symbol: A letter, figure, other character, arrow, mark or any combination thereof used for designating something else by association, resemblance or convention.

useful field of view (UFOV): The sensory, perceptual and attentional processes that address the ability to attend to one's surroundings, detect information and identify that which demands action. In terms of behavior, UFOV includes that information which can be extracted from a glance.

vestibule: An area of a passenger car that normally does not contain seating, is located adjacent to an exterior side door, and is used in passing from a seating area to an immediate exterior side door exit. In some cases used to pass from a seating area space adjacent to an immediate end-frame door exit.

vestibule door: A door separating a seating area from a vestibule and complying with 49 CFR § 238.112(f) if located in the passenger car's designated exit path. Doors separating sleeping compartments or similar private compartments are not vestibule doors.

Abbreviations and acronyms

ADA	Americans with Disabilities Act
ANSI	American National Standards Institute
ASQ	American Society for Quality
ASTM	ASTM International (formerly American Society for Testing and Materials)
CFR	Code of Federal Regulations
CIE	Commission Internationale de l'Eclairage (International Commission on Illumination)
EL	electroluminescent
FAA	Federal Aviation Administration
fc	foot-candles
fl	foot-lamberts
FRA	Federal Railroad Administration
ft	feet
HEP	head-end power
HPPL	high-performance photoluminescent
LED	light-emitting diode
LLEPM	low-location exit path marking
mcd	millicandelas
mcd/m^2	millicandelas per square meter
NTSB	National Transportation Safety Board
PL	photoluminescent
PRESS	Passenger Rail Equipment Safety Standards
SI	Système International
sr	steradian
UFOV	useful field of view

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Appendix B (informative): HPPL material technical considerations

B.1 Variables

Five variables affect the visibility of the HPPL material/component:

- location of the material in relation to the activating charging light
- illuminance charging levels provided by ambient light
- amount of time the HPPL material component is exposed to light
- type of activating light source
- energy-storage efficiency of the HPPL material

The location of the HPPL material in relation to the activating light source and any objects that cast shadows on the material have a great impact on the illuminance provided by the charging light. Accordingly, HPPL material should not be located in shadowed areas.

Cool-white fluorescent lamps producing an illuminance level of 2 fc have been shown to provide sufficient charging light for materials meeting the former definition of HPPL used in passenger railcars. Adequate charging light for HPPL materials/components is generally available at most locations, except directly under the seats, or if there are overhangs or other obstructions that block light from reaching the material/ component. Signs/markings certified according to the former definition of HPPL (see “Definitions”) require at least twice as much illuminance as the currently defined HPPL material to deliver the same luminance. HPPL materials certified to the former definition were usually designed with a large safety factor, so they do not actually require five times as much light for charging as the HPPL material as per the current definition.

Another variable is the available HPPL charging time. The adequate charging time at 1 fc is at least 60 minutes from dark storage until departure.

The type of charging light that is used will affect the amount of illumination required to charge the emergency sign and LLEPM components adequately. Most of the visible spectrum (red, orange and yellow) of a light source is not useful for charging PL materials. Short-wavelength ultraviolet light is the most effective part of the light spectrum for charging PL materials. Photons of longer wavelength do not have enough energy to excite the electrons of the PL material. For example, 1 fc of illumination from a commonly available cool-white fluorescent lamp will provide sufficient illumination to meet the HPPL luminance criterion. However, 1 fc of illumination from commonly available warm-white fluorescent and incandescent lamps will not. If warm-white fluorescent lamps are used, then the minimum charging light level must be at least 50% higher. If incandescent lamps are used, then the minimum charging light level will be more than three times higher than is sufficient with cool-white fluorescent lamps.

White LED light contains a higher proportion of short-wavelength light, and is thus somewhat more effective than cool-white fluorescent light for charging. In addition, since LEDs are fundamentally unidirectional light emitters, luminaires that use them must be specifically designed to disperse light through the use of multiple emitters pointing in different directions, reflectors and/or diffusers. Therefore, it is important that procurement documents explicitly state the illuminance levels required on the surface of the PL signs/markings.

In addition to these five variables, an important consideration is the type of light meter used to measure the charging light illuminance and the placement of the meter sensor in relation to the HPPL material, both of which will have an impact on the ability to accurately measure the illuminance level provided by the activating light source. Light meters are designed to respond to light the same as the human eye does and thus measure only the visible light emitted by both the charging source and the PL material. Although invisible ultraviolet light is the most effective part of the light spectrum for charging PL materials, standard light meters do not register the ultraviolet light emitted by the charging light. Moreover, the weighting factor for visible violet and blue light is small. Therefore, light meter readings of charging light can be misleading if the light source is different from the specified cool-white fluorescent source used for certification (i.e., laboratory) testing. See Appendix C.1 for further information relating to light meters.

B.2 Alternatives to increase charging light output

To ensure that the normal lighting system provides an adequate charge to the HPPL system, luminaires shall be oriented to ensure that the HPPL material is adequately exposed to charging light. This appendix contains information that railroads can use to ensure that sufficient light is available.

If, during the interior verification tests or periodic inspections, the normal charging light fails to meet the minimum illuminance criterion using normal lighting, there are several actions that can be taken to increase the charging light levels:

- Check the light fixtures near the test samples to ensure proper working order.
- Clean light fixtures and check to ensure that the diffusers are not yellowed with age. Old, dirty fixtures have been measured with less than half the light output of clean ones with new diffusers.
- Check fluorescent tubes to ensure that they are not near the ends of their service lives, when light output drops significantly.
- Relocate signs/markings/delineators.
- Replace warm-white fluorescent lamps with cool-white fluorescent lamps.
- Replace/supplement incandescent luminaires with fluorescent or LED luminaires.
- Replace frosted light diffuser lenses with clear lenses.
- Replace existing fluorescent tubes with those of recent design that provide 10% to 15% more light for the same wattage rating and double the service life.
- If the charging light performance criterion cannot be met after taking the above actions, then install either:
    - PL signs/markings/delineators verified by the manufacturer/supplier-provided independent laboratory certified test result to exceed HPPL requirements sufficiently that they can provide a luminance of 7.5 mcd/m^2 after 90 minutes, as applicable (for exceptions, see Appendix G), after charging with whatever normal lighting is available at the sign/marking/delineator location in question; or
    - dual-mode or actively illuminated components with an independent power supply.

B.3 Testing considerations

The difference between the physical characteristics of electrically powered light fixtures/strips and HPPL materials has an impact on their visibility and thus the performance criteria and installation location within various railcar configurations. For example, it is important that HPPL material be installed in locations and orientations that provide maximum exposure to adequate charging light. In addition, dual-mode LLEPM system components can be used to increase conspicuity. Additional measures for addressing extenuating circumstances are described below and in Appendix B.2.

If the ambient light cannot be reduced to 0.01 fc, there are two alternative measurements that can be used to meet the requirements (see Section 2.4.2.2):

1. Measure the ambient light at each location and subtract that value from the value measured with the charging light system operating.
2. If the charging light system is at least twice the required levels in **Table 1** plus the ambient light reading, consider the required levels to be met.

If the ambient (normal charging light) illuminance is less than the required criteria specified, railroads can take several actions described in this appendix to increase the charging light levels.

Unless the floor measurement value is known to be at least five times the value in **Table 1**, a 6½ ft (1.98 m) separation between the sensor head and the display must be used to ensure that the proximity of the person taking the measurements does not affect the readings.

TABLE 1
Minimum Illuminance Values for Charging HPPL Materials (Former and Current Definitions), Grandfathering

Illuminance Value, fc (lux)		Type of Luminaire (Charging Light)
Certified Under Former Definition of HPPL	**Certified Under Current Definition of HPPL**	
1.6 (10.8)	0.8 (8.6)	Cool-white LED (6500 ºK)
1.8 (19.4)	0.9 (9.7)	Warm-white LED (4700 ºK)
2.0 (21.5)	1.0 (10.8)	Cool-white fluorescent (4000–4500 ºK)
3.0 (32.3)	1.5 (16.1)	Warm-white fluorescent (3000–3500 ºK)
7.0 (75.3)	3.5 (37.7)	Incandescent (2900 ºK)

HPPL materials certified by an independent test laboratory to meet **Table 1** requirements with the lower amount of charging light are permitted for use at that location, as long as the specified amount of light is available.

To the extent practicable, avoid installing HPPL signs/markings in shadowed locations.

HPPL signs/markings certified by an independent test laboratory to be capable of meeting the minimum performance specifications of HPPL as defined in this standard that are located in partitioned vestibules/ compartments/passageways no longer than 5 ft (1.52 m) longitudinally (including partially portioned vestibules) are not subject to the illuminance requirements in **Table 1**.

Luminaires located in the proximity of each HPPL component shall be specified such that their light-dispersion patterns provide the above-listed minimum illuminance levels at the surface of the component.

Existing stocks of PL material held in inventory as of April 7, 2008, that meet the former definition of HPPL may be installed only in locations that qualify under one of the conditions listed above and that are not shadowed by structural elements or other permanent fixtures.

A list of independent test laboratories is contained in Appendix E.

The manufacturer/supplier is required to have a minimum of one batch of material for signs/markings/ delineators of a given type certified. Signs/markings/delineators of the same certified type of material can be sold to multiple customers, even with minor changes in text or typography.

Several methods can be used to eliminate ambient light for accurate data collection (e.g., work at night with cars parked away from bright yard lights; locate cars in a dark, windowless shop or carwash; mask windows and vestibules with roofing paper, flooring paper or similar opaque materials; or drape cars with opaque tarps).

To take the measurement readings, the sensor is placed on the area of the HPPL sign/marking surface location where the light is brightest (or on the floor location as permitted in Appendix G.1.2). The observer records the reading(s) using a data collection form (see Appendix C.4).

The sensor and the readout device of the illuminance meter must be held in a manner so that the sensor is not affected by the observer’s shadow. If light diffusers are used on the light fixtures, then the measurements shall be made with the light diffusers in place.

Appendix C (informative): Procedures for measuring charging light illuminance

C.1 Equipment

Examples of handheld meters on the market with adequate accuracy and sensitivity for this application are illustrated in **Figure 1**.

FIGURE 1
Typical Meters for Illuminance Measurements

Hagner E4-X digital luxmeter

Minolta T-10A illuminance meter and A20 and A21 adapters and LAN cable

Gigahertz-Optik X1 with VL 3704 illuminance detector

Other meters that meet the performance specifications listed in Section 3 are also acceptable.

Illuminance sensors may need recalibration if they are dropped. Special care is required to avoid this. Gigahertz-Optik offers an optional foam rubber shock protector for its sensor.

Railroads with fleets consisting entirely of brightly illuminated cars may forgo the use of a meter with precise off-axis response, because high levels of floor illumination can be used to establish that illumination on vertical surfaces is adequate for charging PL emergency signage and LLEPM components. Low-cost meters that conform to CNS 5119, Class II (which permits unlimited errors for angles of incidence greater than 60 deg) may be used for floor and arm-rest level measurements of illumination. Because field data have shown that illuminance values on vertical surfaces are at least 20% of the illuminance on adjacent floors, the floor measurements made with inexpensive meters can be used to demonstrate compliance with this standard whenever the values at the floor are five times greater than required illuminance on the surface of the LLEPM component in question. Meters for this application are widely available from vendors such as Extech, TES, Tenmars, etc.

Other considerations: The Minolta meter can be set to read out in foot-candles or lux; the other meters read out in lux only. The Minolta and Gigahertz-Optik meters have USB data outputs. The Hagner meter has an analog data output and requires an external USB data-acquisition adapter. The Minolta meter has a detachable head that can be connected to the meter body with an ordinary LAN cable of 6½ ft (1.98 m), provided that the optional A20 and A21 adapters are purchased. The other meters have 6½ ft (1.98 m) cables permanently attached to the sensor.

C.2 Data recording and computerized data collection

To take the measurement readings, the sensor is placed on the area of the HPPL LLEPM component or emergency sign surface location where the light is brightest (or on the floor location as permitted in Appendix G.1.2). The observer simply records the reading(s) using a form similar to that shown in Appendix C.4.

The sensor and readout device of the illuminance meter should be held in a manner so that the readout device can be read without the observer's shadow affecting the readings.

The illuminance measurements described in Section 2.4 for the doors, vestibules, stairs, etc., must be performed by manually positioning the light sensor at each of the designated locations. However, the numerous aisle measurements to determine the minimum average illumination levels required in **Table 1** can be taken much more quickly and more accurately using a computer. The computer data collection technique is based on moving/dragging a sensor down the aisle at a slow, steady pace while readings are captured to a notebook computer or data logger at the rate of at least one reading per second.

Although no special apparatus is needed to collect floor-level measurements, it is strongly recommended that the notebook computer, light meter and any adapters be attached to a tray or similar carrying device with hook-and-loop tape so they can be easily and safely moved together.

The spatial average is calculated with spreadsheet software based on 60 or more samples, i.e., the data collector should walk at the rate of about one foot per second. The software will also find the minimum value in each set of readings and generate a graphic profile of illuminance levels along the length of the car.

As noted in Section 3.1.2.1, the minimum test period duration is 90 minutes. All illuminance light levels are measured and recorded immediately at the start of the test, at the halfway time point, and again at the end of the final time duration.

C.3 Timing of readings

Readings should be taken at least 15 minutes after the normal illumination charging light is placed in operation to allow the lamps to reach full output and per Section 3.

C.4 Sample illuminance charging light survey forms

C.4.1 Signage/marking sample illuminance/charging light survey form

Railroad Property/Location:		
Car Builder:		
Car Type/Series/Configuration/Year:		
Car Plate #:		
Date:		
Data Collector's Name:		
Light Meter Used:		
Start Time:	End Time:	
MEASUREMENTS (all measurements are expressed in foot-candles)		
Locations	**A-End**	**B-End**
End door sign/control/instructions		
Side door sign, location 1		
Side door sign, location 2		
Side door sign, location 1		
Side door sign, location 2		
Window exit locator signs (describe location and record measurement at each sign)	**Left Side**	**Right Side**

C.4.2 LLEPM sample illuminance/charging light survey form

Railroad Property/Location:	
Car Builder:	
Car Type/Series/Configuration/Year:	
Car Plate #:	
Date:	
Data Collector's Name:	
Light Meter Used:	
Start Time:	End Time:

MEASUREMENTS (all measurements are expressed in foot-candles)		
Locations	**A-End**	**B-End**
End-frame door sign/control/instructions		
Vestibule door, location 1		
Vestibule door, location 2		
Stairs, location 1		
Stairs, location 2		
Aisle, location 1		
Aisle, location 2		
Crew area (if any)		
Other special area		
Passageway, if any		

C.4.3 Notes form

Use the following to describe the make, model, wattage rating and cleanliness of the emergency charging light fixtures, etc.

Appendix D (informative): Automatic testing of electrically powered systems

Electrically powered emergency signage and LLEPM components using independent power sources have important advantages since they are not vulnerable to loss of the main car battery power supply and/or damage to the main car battery power supply wiring.

All passenger cars equipped with electrically powered path markings/delineators that are not dual mode shall have an independent power source. Batteries that are used as independent power sources shall have automatic self-diagnostic modules designed to perform discharge tests (see below).

Finally, LED-based dual-mode signage/marking components should use either white or green charging light.

For the independent power supply to the emergency signage and LLEPM system to be reliable and operate when necessary, multiple individual batteries must be periodically tested for each railcar (for cars with only two such batteries, each one must be tested).

Manual testing requires that a worker first determine that all independent power sources using batteries have been connected to a source of charging power for the necessary amount of time to reach full charge. Then, car by car, the charging power must be disconnected and the LLEPM system and emergency signage switched into emergency mode. After the prescribed 90-minute time period for discharge (except as noted in Appendix F), the worker must then revisit each car and note which LLEPM and emergency signage components are working properly and which are not. While such tests are in progress, other kinds of maintenance work are effectively precluded by the lack of light inside the car. Frequency of testing is governed by OEM specifications.

To avoid the substantial labor costs of conducting periodic discharge tests of these independent power sources, manufacturers of door emergency exit sign systems for buildings have developed self-test modules for their battery ballasts that perform periodic discharge tests automatically. (A discharge test is necessary for independent batteries because they are sealed devices and therefore cannot be tested by the specific-gravity method used for the main car battery.)

These self-test modules display the results of the most recent test by means of a multicolor LED on the light fixture. For a typical fixture, the LED can indicate any of the following conditions:

Condition	Status Indication
Normal mode	Steady green
Self-testing	Flashing green
Emergency mode	Off
Insufficient charge	Flashing red/green
Battery pack failure	Single-flash red
Emergency lamp failure	Double-flash red
Self-diagnostic module failure	Triple-flash red
Under/over charge	Quadruple-flash red

The status indication remains displayed until the next scheduled periodic test or until a repair is performed. Only a momentary observation is required to see that a unit is functioning normally. Only failed components require action by maintenance staff.

Automatic testing offers the important advantage of allowing one worker to determine the condition of every LLEPM and emergency signage component in the time it takes to walk the length of an entire train and requires no special preparation. In addition, it is not necessary to turn off normal lighting, so there is no interference with other inspection and maintenance activities.

All the test modules on the market are microprocessor-based. The frequency and duration of the discharge tests are specified in software. Test modules for the commercial building market perform 5-minute discharge tests at 30-day intervals and 30-minute discharge tests at 6-month intervals.

Appendix E (informative): Test laboratories

E.1 ASTM International

At the time this document was authorized, the following independent test laboratories could perform the ASTM E-2073 test, as noted in Section 3.1.2.1 of this standard to measure the luminance of HPPL material:

- California Institute of Electronics and Material Science (www.ciems.com/)
- Intertek ETL Simko (www.intertek-etlsemko.com/)
- Gamma Scientific (www.gamma-sci.com)
- UL Inc. (www.ul.com)
- Hoffman Engineering Corp. (www.HoffmanEngineering.com)

E.2 UL

UL (formerly Underwriters Laboratories) has issued UL 1994, "Standard for Luminous Egress Path Marking Systems." UL 1994 includes requirements for egress path marking installed for buildings in accordance with NFPA 70, "National Electrical Code," and NFPA 101, "Life Safety Code." The NFPA 101 and UL 1994 requirements now reflect acceptance of PL signs for use in buildings.

While this APTA standard contains requirements consistent with the general concepts of UL 1994, the UL tests and performance criteria are not considered appropriate to evaluate passenger railcar emergency signage and LLEPM systems.

Appendix F: Sampling (normative)

F.1 Representative sample sizes

Either of the following two sampling methods is acceptable.

F.1.1 ANSI/ASQ

The American National Standards Institute (ANSI) and the American Society for Quality (ASQ) have developed detailed procedures for determining representative sampling plans for maintenance inspection operations. These may be found in “Sampling Procedures and Tables for Inspection by Variables for Percent Nonconforming” (ANSI/ASQC Z1.9-2003). In Appendix A7.1 of this standard, various inspection levels, which allow for alternative sample sizes, are explained. When operations do not permit the preferred inspection level of “General II” to be carried out, “Special Inspection Levels” (S3) may be used. If the total car fleet is smaller than the number of samples required by ANSI/ASQC Z1.9-2003, then the sample size is equal to the car fleet size.

In determining whether to accept or reject the fleet’s emergency light performance, the methods of Appendix B, Form 2 should be used, since variability of the fleet, or “lot,” is unknown. Additionally, a Quality Acceptance Limit of not more than 2.5% shall be used, per industry practices.

If the first sample has acceptable results, as defined by ANSI/ASQC Z1.9-2003, no further action is needed. If the sample fails, a new sample should be tested using “tightened” inspection procedures. If the new sample passes, document and correct any single car/area that failed to meet the criteria of Table 1, Section 6, of this standard. After completion of the repair, no further action is needed. If the second sample fails, determine the cause, document, and implement a fleet-wide redesign/repair to correct the defect. Upon completion of repairs, reinspect using tightened inspection procedures.

Areas of similarity within a vehicle do not require additional testing.

F.2.2 Determining fleet size for sampling purposes

Cars of different manufacturers or different marking/signage designs cannot be considered as part of the same fleet when considering sampling for periodic testing.

Justification shall be provided if a railroad elects to include similar yet different rolling stock within the same fleet for sampling purposes. Examples of this include, but are not limited to, the following:

- cab cars, trailer cars, power cars, MUs, and cab cars running as trailer cars
- different car orders
- identical areas across multiple variants of the same base design

Justification for the inclusion of similar yet different rolling stock within the same fleet for sampling purposes shall include either numerical or logical proof that the inclusion of the similar yet different cars shall not create a false positive sampling for any of the sub-fleets included. If sub-fleets are included within the same sample set, at least one sample from each sub-fleet shall be included within the sample set.

Appendix G (informative): Grandfathered systems and materials

The following grandfathered exceptions apply only as described below.

G.1 PL materials

Existing stocks of PL material held in inventory as of April 7, 2008, that meet the former definition of HPPL may be installed only in locations that qualify under one of the conditions listed in Appendices G.1.1 and G.1.2 and that are not shadowed by structural elements or other permanent fixtures.

PL materials that meet the luminance levels of at least 7.5 mcd/m^2 for at least 60 minutes following a charge with the illuminance values in **Table 1** (see Appendix B.3) are grandfathered. If PL materials certified by an independent laboratory to meet the former definition of HPPL are charged with the illuminance levels in the first column of **Table 1**, then such materials are presumed to meet these luminance levels.

G.1.1 Signs/markings

PL signs/markings installed in cars on or before April 7, 2008, and certified by an independent test laboratory to comply with the PL luminance criteria in Appendix G.1 are grandfathered if any of the following conditions are met:

1. The location where they are installed receives the minimum illuminance listed for the type of luminaire used for charging as specified in **Table 1** (see Appendix B.3). The illuminance values shall be measured with a light meter meeting the requirements in Section 3.1.3 and Appendix C and with the sensor placed flat against the surface of the sign/marking.
2. The illuminance values shall be measured with a light meter meeting the requirements in Appendix C, except that its cosine error may be as specified in CNS 5119 (see Appendix C) and with the sensor placed flat on the floor at any point within a horizontal distance of 3 ft (0.914 m) of the sign/marking. The illuminance values shall be at least five times greater than the values listed in **Table 1**.
3. The signs/markings are made of materials meeting the former definition of HPPL located in partitioned vestibules/compartments/passageways that are:
    - no longer than 5 ft (1.52 m) longitudinally (including partially partitioned vestibules); or
    - between 5 and 10 ft (1.52 and 3.05 m) in length measured longitudinally (including partially partitioned vestibules) that are charged by incandescent luminaires, and have:
        - locator signs in the seating area that comply with Sections 2.1.1.4 and 2.1.2.1, and:
        - dimensions of at least:
            - 2 in. (5.08 cm) in letter height; or
            - 21 sq in. (135 cm^2) in area.

NOTE: Some signs/markings may have to be replaced or some illumination levels increased. If the ambient illuminance (normal charging light) is less than the required criteria specified, then railroads can take several actions described in Appendix B to increase the charging light levels.

G.1.2 LLEPM components

PL LLEPMs installed in cars on or before April 7, 2008, and certified by an independent test laboratory to comply with these PL luminance criteria in Appendix G.1 are grandfathered if any of the following conditions are met:

1. The location where they are installed receives the minimum illuminance listed for the type of luminaire used for charging as specified in **Table 1** (see Appendix B.3). The illuminance values shall

be measured with a light meter meeting the requirements of Appendix 3.1.3 and Appendix C and with the sensor:
- placed flat against the surface of the LLEPM sign/marking/delineator; or
- dragged along the aisle while its data is recorded by a notebook computer or data logger, as described in Appendix C, for exit path marking/delineators installed near or in the floor.

2. The illuminance values shall be measured with a light meter meeting the requirements in Section 3.1.3, except that its cosine error may be as specified in CNS 5119 (see Appendix C) and with the sensor placed flat on the floor at any point within a horizontal distance of 3 ft (0.914 m) of the sign/marking/delineator. The illuminance values shall be at least five times greater than the values listed in **Table 1** (see Appendix B.3).
3. The signs/markings are made of materials meeting the former definition of HPPL located in partitioned vestibules/compartments/passageways that are:
   - no longer than 5 ft (1.52 m) longitudinally (including partially partitioned vestibules); or
   - between 5 and 10 ft (1.52 and 3.05 m) in length measured longitudinally (including partially partitioned vestibules) that are charged by incandescent luminaires, and have:
     - locator signs in the seating area that comply with Sections 2.1.2.1 and 2.1.2.2; and
     - dimensions of at least:
       - 2 in. (5.08 cm) in letter height; or
       - 21 sq in. (135 cm^2) in area.

NOTE: Some signs/markings may have to be replaced or some illumination levels increased. If the ambient illuminance (normal charging light) is less than the required criteria specified, then railroads can take several actions described in Appendix B to increase the charging light levels.

G.2 Alternative markings

G.2.1 Door control markings

Each door exit handle, latch, or operating button may be marked with HPPL material in the form of an area wide pad that is applied to the door or doorframe directly behind the handle or latch with either of the following dimensions:

- For equipment ordered before April 7, 2008, and placed in service before Jan. 1, 2011, no less than 6 sq in. (39 cm^2).
- For equipment ordered on or after April 7, 2008, or placed in service for the first time after Jan. 1, 2011, no less than 16 sq in. (103 cm^2).

G.2.2 Pathway and stairway markings

Previous revisions specifically cited the following three stairway marking alternatives as acceptable if the marking/delineator placement provides a clear and conspicuous visual delineation of the exit path to a person standing at the top landing, bottom landing and any tread:

- **Alternative 1:** 1 in. (2.54 cm) wide “L” shaped marking/delineators shall be installed on both sides of each tread nearest to the wall.
- **Alternative 2:** Materials applied to the step risers that consist of a minimum 2 in. (5.08 cm) wide strip or two 1 in. (2.54 cm) wide strips that extend, to the extent practicable, across the full width of the riser and placed at the lower half of the riser.
- **Alternative 3:** Discs of not less than 1.25 in. (3.18 cm) in diameter, placed either:
  - no more than 2.5 in. (6.35 cm) apart on each stair tread, near the step nosing; or
  - no more than 2.5 in. (6.35 cm) apart and no higher than 18 in. (45.7 cm) from the treads on both sides of the stairway walls/partitions.

Additionally, each passenger car ordered before April 7, 2008, and placed in service before Jan. 1, 2011, may have pathways marked by three discs clustered in a series with no gap between the clusters exceeding 30 in. (76.2 cm).

G.2.3 Vestibule, end-frame and side doors

Emergency exit signs/markings shall identify the location of all vestibule, end-frame and side doors leading to the exterior of the car and intended for emergency egress using the following:

1. For passenger cars ordered before April 7, 2008, and placed in service before Jan. 1, 2011:
    - HPPL material, including dual-mode; or
    - electrically powered fixtures with an independent power source that can power the signs for at least 60 minutes after power for normal lighting ceases.

For passenger cars ordered before April 7, 2008, and placed in service before Jan. 1, 2011, each electrically powered sign/marking that is not dual mode shall have an independent power source that can power the sign/marking in accordance with the requirements above.

G.3 Other grandfathered requirements

The following are other dated implementation requirements that have already passed. Existing installations are grandfathered only if installed before the implementation date of each requirement. Existing installations that are grandfathered are to be upgraded to become compliant upon replacement.

G.3.1 Sign size

A minimum sign area of 16 sq in. (103 cm^2) is required for all end and side door exit signs installed after April 7, 2008.

G.3.2 Exposed LED exit signs

For signs/markings installed on or after April 7, 2008, with exposed LEDs that spell out “EXIT,” each LED shall have a minimum peak intensity of 35 mcd.

G.3.3 Evaluation measurements and tests of interior signs/markings

For equipment placed in service before Jan. 1, 2008, the cars/areas shall be randomly selected and the qualification test(s) shall be conducted by Dec. 31, 2008. For equipment placed in service for the first time on or after Jan. 1, 2008, the first car to have the system installed may be tested and this test shall be completed prior to the car’s release for operation in revenue service.

G.3.4 Independent power sources for electrically powered systems

For passenger cars ordered before April 7, 2008, and placed in service before Jan. 1, 2011, electrically powered path markings/delineators that are not dual mode shall have an independent power source by Jan. 1, 2012. Batteries that are used as independent power sources shall have automatic self-diagnostic modules designed to perform discharge tests (see Appendix D.)

G.3.4.1 Semi-permanently connected trainsets

For passenger cars ordered before April 7, 2008, and placed in service before Jan. 1, 2011, independent power sources for LLEPM systems are not required in passenger cars that are part of semi-permanently coupled trainsets, if the power source is a sealed battery located above the underframe of the car.

G.3.5 Point source/strip illuminance/luminance intensity

For point sources/strips installed in each passenger car ordered on or after April 7, 2008, or placed in service for the first time on or after Jan. 1, 2011, each point source/strip shall comply with the following criteria:

- **Incandescent:** miniature lamps not less than 150 mcd mean spherical intensity with a maximum spacing of 4 in. (10 cm) between lamps.
- **LED:** minimum peak intensity of 35 mcd with a maximum spacing between lamps of 12 in. (30.5 cm). LED-based dual-mode components shall use either white or green charging light.

Appendix H (informative): APTA passenger rail emergency systems survey

H.1 Survey questions

Instructions/contact info

The survey below is intended to gather information on industry practices regarding emergency communication systems, in-car signs/maps, primary exit path operation and demarcation, in-car stairway emergency markings, and high-performance photoluminescent (HPPL) material testing.

1. Contact info:
    a) Name of primary filer
    b) Title
    c) Transit agency/organization
    d) Email address
2. Are you employed by a (select one):
    a) Railroad/transit agency
    b) Manufacturer

Crew-to-passenger communications systems

1. Indicate each of the following that are part of your railroad's crew-to-passenger emergency communication system:
    - Intercom
    - Public address systems
    - Brochures describing emergency egress procedures
    - Signage denoting a locked exit path
    - Automatic messaging
    - Other (write in)
2. Does your system use station, wayside, landline or block line phones in an emergency?
3. Does your system have a policy allowing for direct contact from train crew to emergency responders?
4. Does your railroad have any communication protocols between your OCC and passengers?

Emergency egress signs/maps

1. Do you post emergency egress signs/maps in your railcars?
2. Please identify your most common type of passenger rail vehicle (manufacturer, model name and year).
3. Indicate whether any of the following locations are where emergency egress signs/maps are posted in your most common type of passenger rail vehicle (check all that apply):
    - Vestibules
    - Doors
    - Stairways
    - Bulkheads
    - Other locations (please specify)
4. Please provide photos of example exit orientation signs or graphics and their placement within your most common railcar, if possible.
5. Please provide example pictures of various locator signs in one of your passenger vehicles. If possible, please provide dimensions for the locator signs pictured.
6. Please indicate the vehicle(s) that the pictures of your locator signs came from (manufacturer, model, year).

7. Please indicate how long, in minutes after activation, your backup power source is required to function to power emergency in car systems such as low-level exit path markings, signs and communication systems.
8. Please indicate which, if any, languages other than English are used in emergency egress signs posted in any of your railcars.

High-performance photoluminescent materials

1. What methods has your organization used for measuring performance of high performance photoluminescent (HPPL) material?
2. Would your organization be willing to measure performance of high performance photoluminescent material rather than measuring charging light intensity?
3. What is your organization's current practice regarding determining representative railcar areas?

Doors

1. Please provide photos of the emergency exit systems, including any signs/markings regarding operation, most commonly employed by your commuter railroad in your most common railcar indicated previously.
2. Do you indicate that a door is locked and is not a useable exit path (example: front- and rearmost doors in a multiple unit consist)? If alternative exit paths are indicated at the locked-door location, please provide photos of the indication.

Stairways

1. If you have stairways in your cars, please indicate the vehicle model and provide photos of your most common and most unusual LLEPM configuration around a car stairway. This includes any accompanying signage, stairway step and tread markings or lighting, stairway side markings or lighting, and upper and lower landing areas.

Kick-out panels

1. How do you interpret the current CFR requirement 49 CFR §238.439(c) regarding kick-out panels and markings?

H.2 Respondents

- ACE
- Alaska Railroad
- Amtrak
- Bombardier
- DCTA
- LIRR
- MARC
- Metra
- Nippon Sharyo
- RTD
- SCRRA
- SEPTA
- Siemens
- Sound Transit
- Talgo
- TriMet
- UTA

H.3 Results

Question		Percent Affirmative
Indicate each of the following that are part of your railroad's crew-to-passenger emergency communication system.	Intercom	77%
	PA	100%
	Brochure	85%
	Locked exit signage	85%
	Automatic messaging	38%
	Other	n/a
Do you post emergency egress signs/maps in your railcars?		94%
Indicate whether any of the following locations are where emergency egress signs/maps are posted in your most common type of passenger rail vehicle.	Vestibules	80%
	Doors	53%
	Bulkheads	26%
	Stairways	13%
	Other	n/a
Please indicate the how long, in minutes after activation, your backup power source is required to function to power emergency in car systems such as low-level exit path markings, signs and communication systems.		90 minutes (60 minutes for grandfathered systems)
Please indicate which, if any, languages other than English are used in emergency egress signs posted in any of your railcars.		Spanish 29% Braille 6% French 12%
Do you indicate that a door is locked and is not a useable exit path (example: front- and rearmost doors in a multiple unit consist)?		65%
Would your organization be willing to measure performance of high-performance photoluminescent material rather than measuring charging light intensity?		46%

Appendix I (informative): Photographic examples

I.1 Exit orientation signs

FIGURE 2
Emergency Evacuation Instructions Example (Metra)

FIGURE 3
Emergency Evacuation Instructions Example (Bombardier)

FIGURE 4
Emergency Evacuation Instructions Example (ACE)

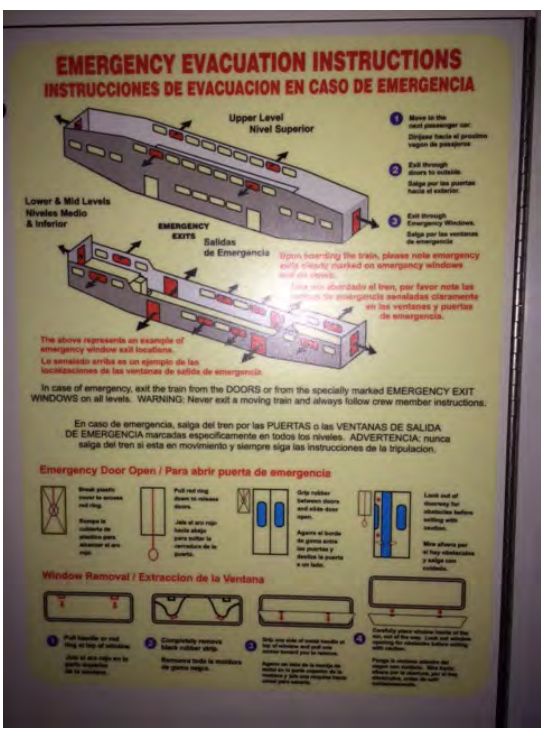


FIGURE 5
Emergency Evacuation Instructions Example (Alaska RR)

FIGURE 6
Emergency Evacuation Instructions Example (UTA)

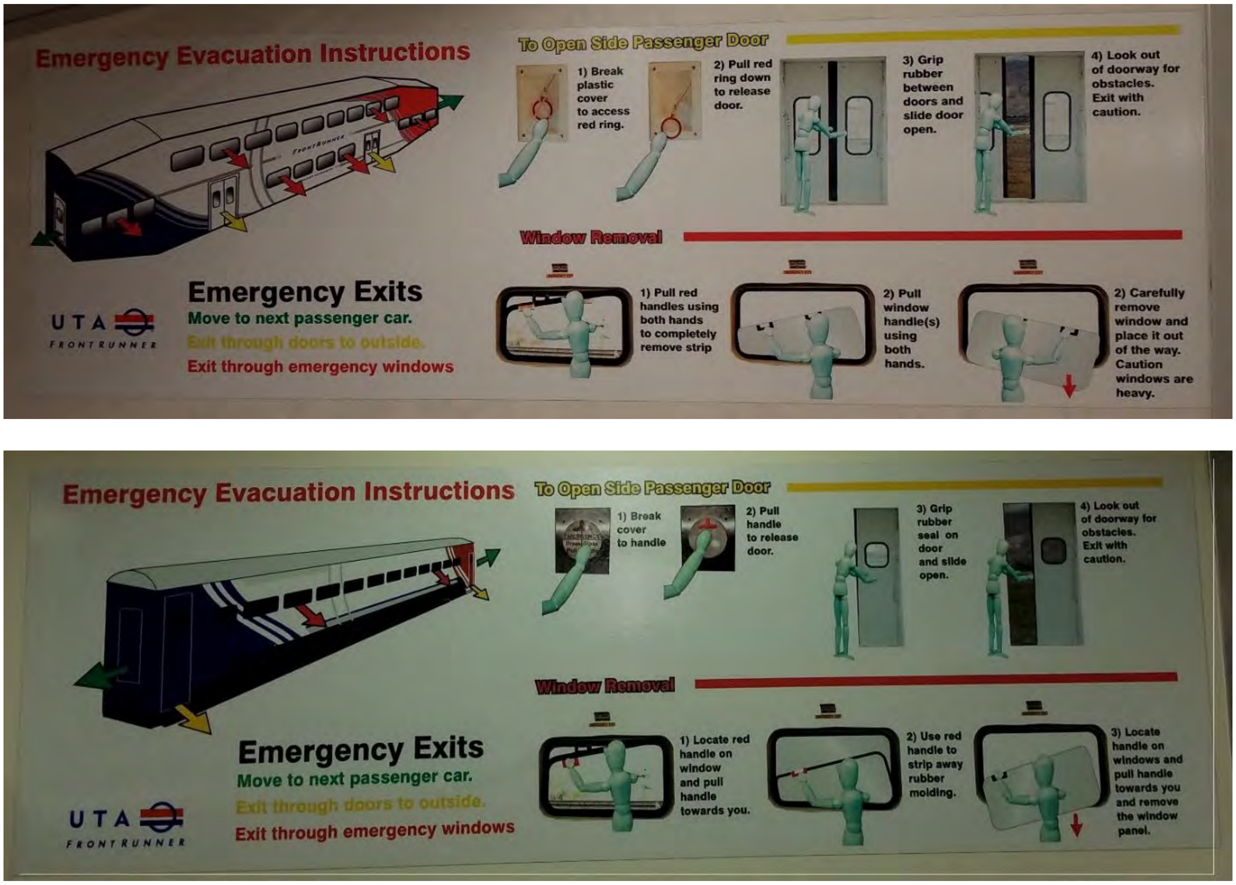


FIGURE 7
Emergency Evacuation Instructions Example (SCRRA)

FIGURE 8
Emergency Evacuation Instructions Example (SEPTA)

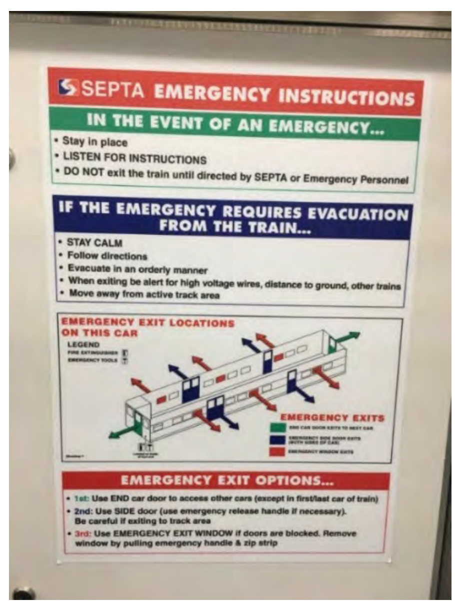
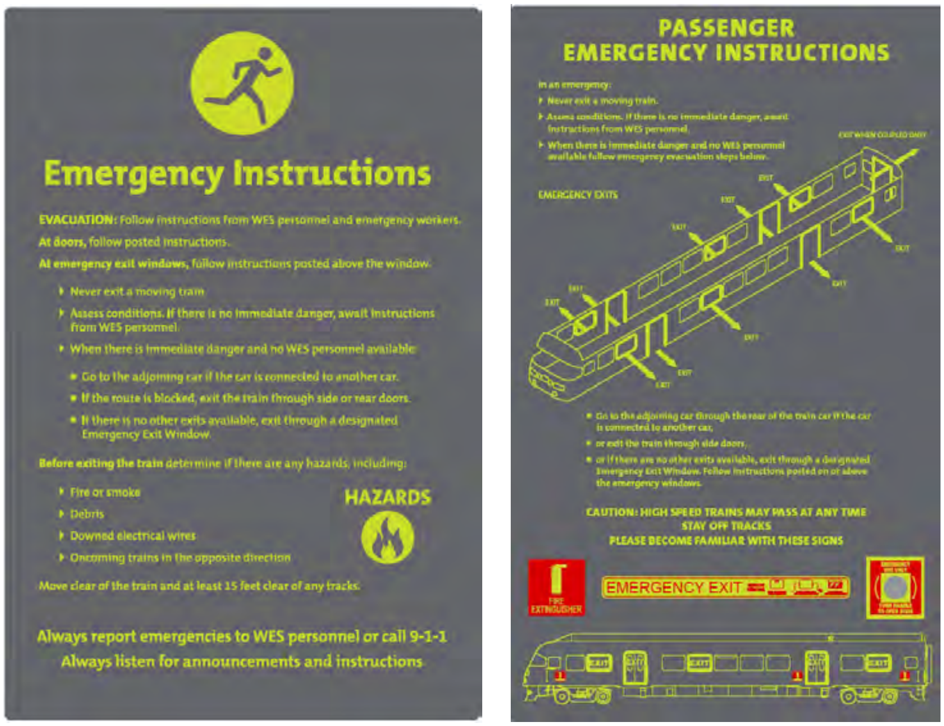


FIGURE 9
Emergency Evacuation Instructions Example (TriMet)



I.2 Locator signs (as described in Sections 2.1.2.1 and 2.1.2.2)

FIGURE 10
Exit Locator Sign Example (Bombardier)

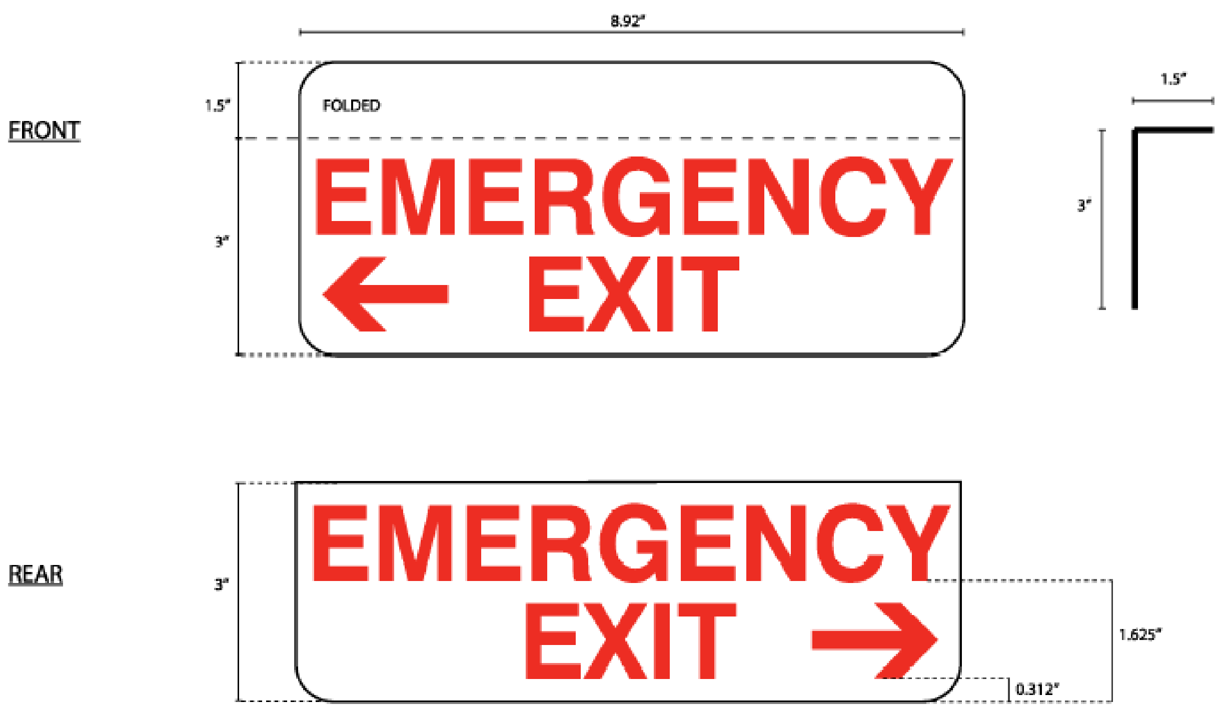


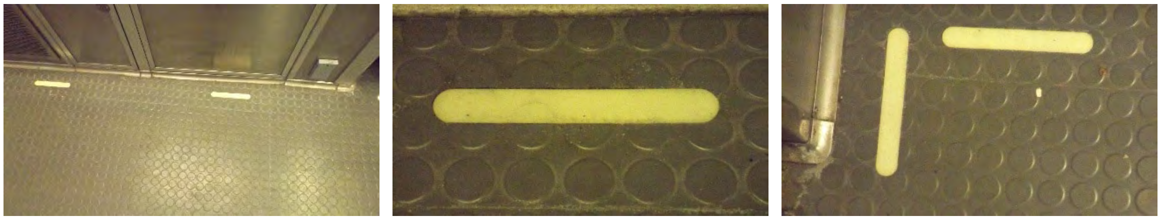
FIGURE 11
Exit Locator Sign Example (Nippon Sharyo)

FIGURE 12
Seat-Mounted LLEPM with Locator Sign (UTA)

I.3 Oblong disc LLEPM (as described in Section 2.1.1.2)

Figure 13 shows pictorial examples of LLEPMs using an oblong disc configuration to fulfill the minimum requirement for intermittent delineators as noted in Section 2.1.1.2.

FIGURE 13
Oblong Disc LLEPM Alternative (Scott Laps)



I.4 Door markings

I.4.1 Primary exit doors

FIGURE 14
Primary Door Exit Markings (Alaska RR)

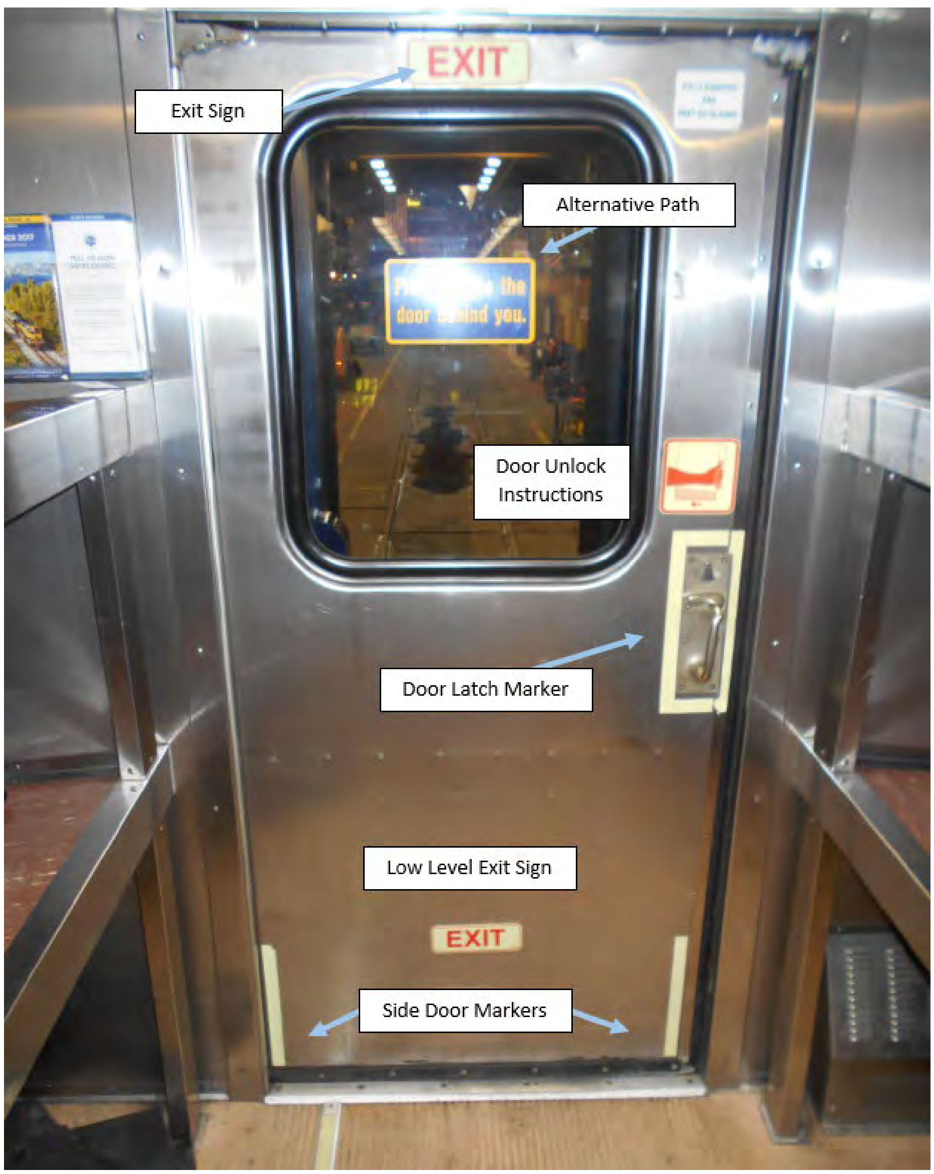


FIGURE 15
Body End Door Markings and Signage (Amtrak)

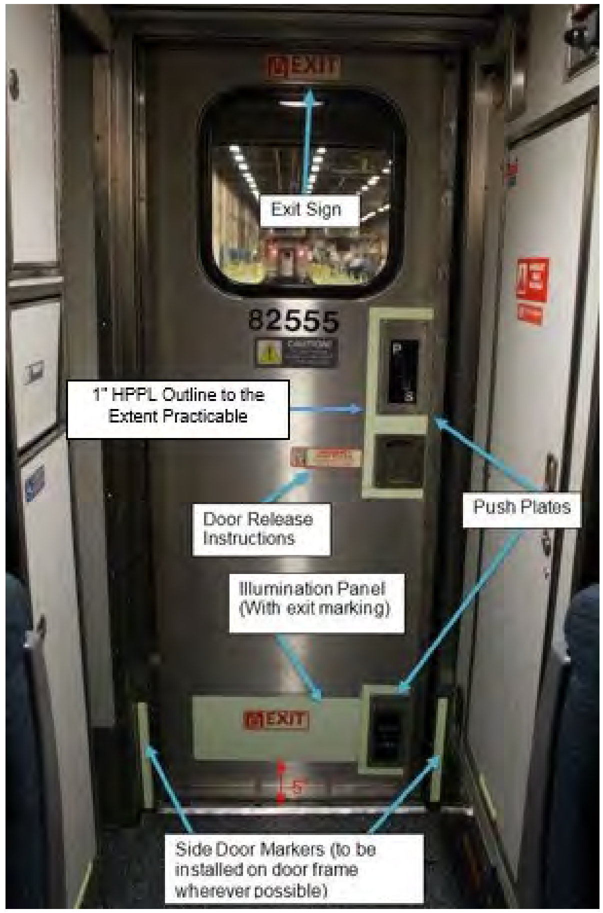
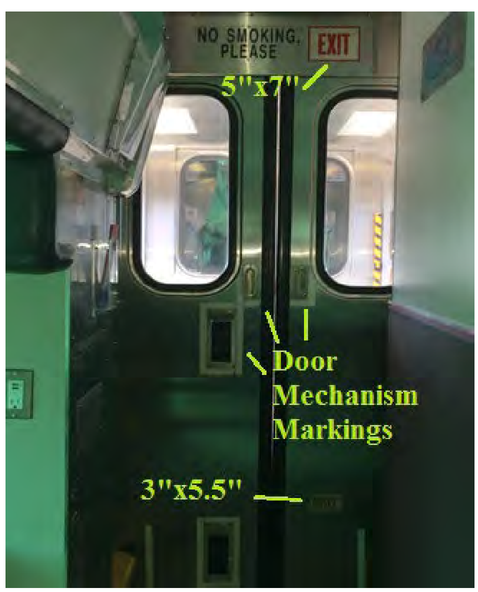


FIGURE 16
Primary Door Exit Markings (Metra)



I.4.2 Routinely locked doors (as described in Section 2.1.3.3)

FIGURE 17
Routinely Locked Door Sign Example (LIRR)

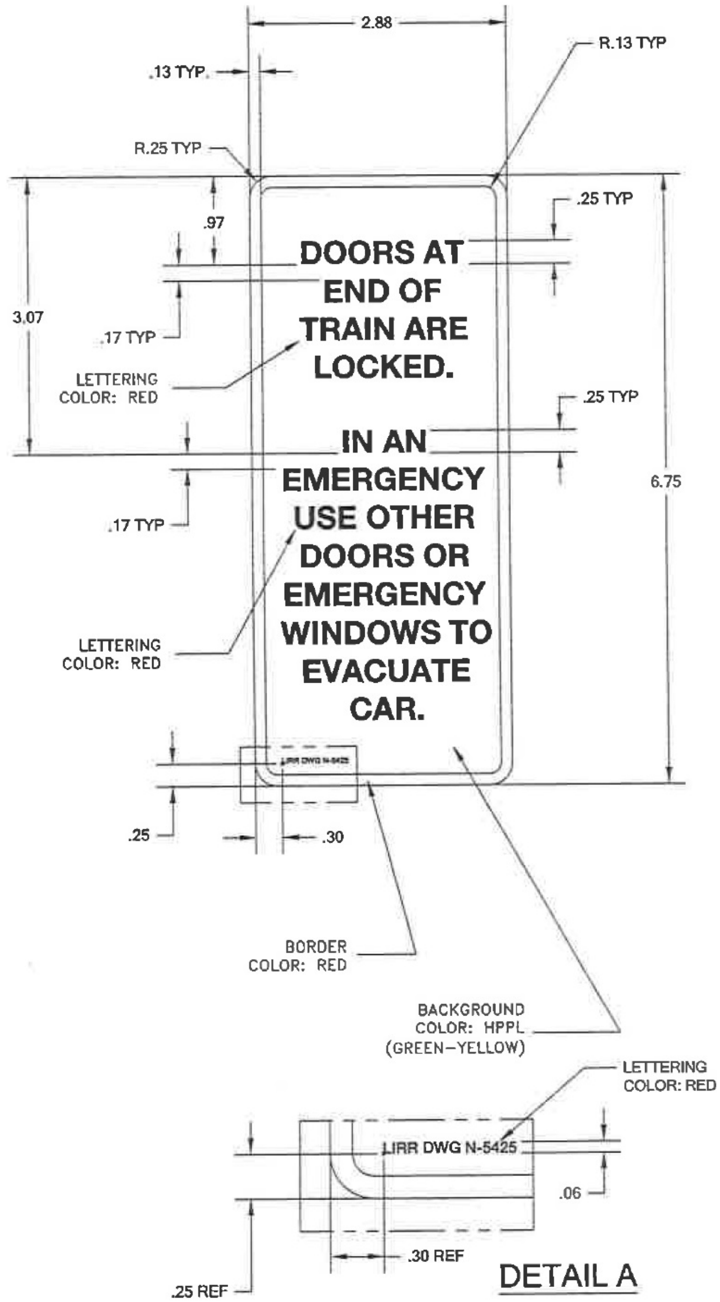


FIGURE 18

Routinely Locked Door Sign Example (Amtrak)

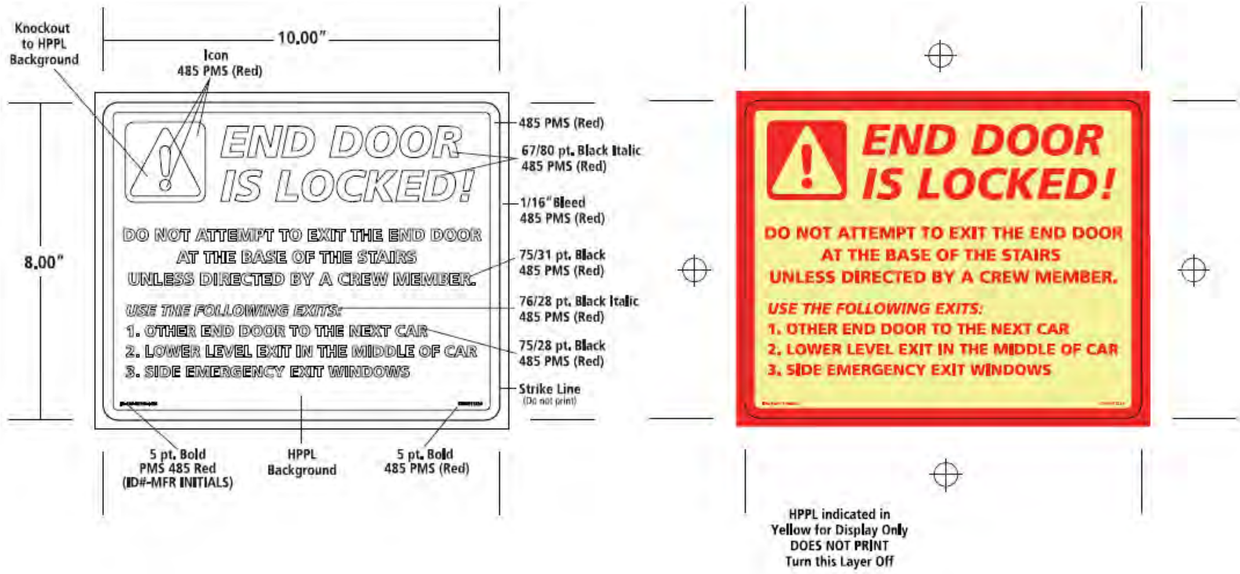


FIGURE 19

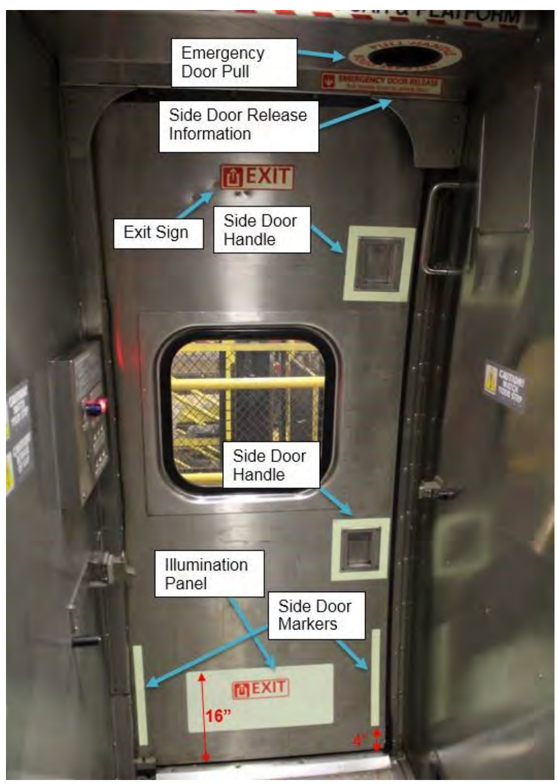
Routinely Locked Door Sign Example (ACE)

I.4.3 Secondary door exits

FIGURE 20
Secondary Door Exit Markings and Signage (Alaska RR)

FIGURE 21
Secondary Door Exit Markings and Signage (SCRRA)

FIGURE 22
Secondary Door Exit Signage and Markings (Amtrak)



I.4.4 Non-obvious door mechanisms

FIGURE 23
Non-Obvious Door Mechanisms Signage (SCRRA)

FIGURE 24
Non-Obvious Door Mechanisms Signage (Alaska RR)

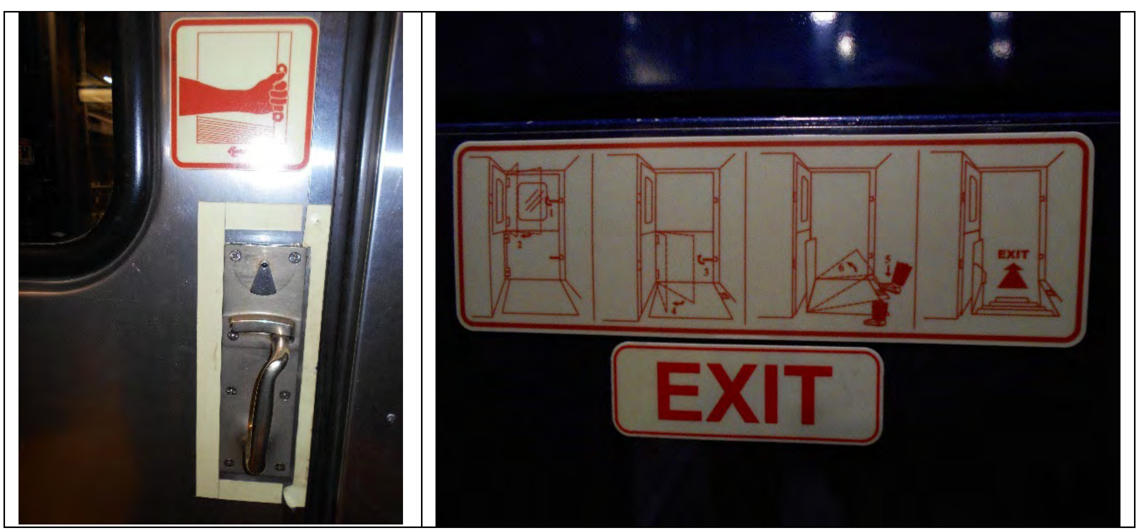


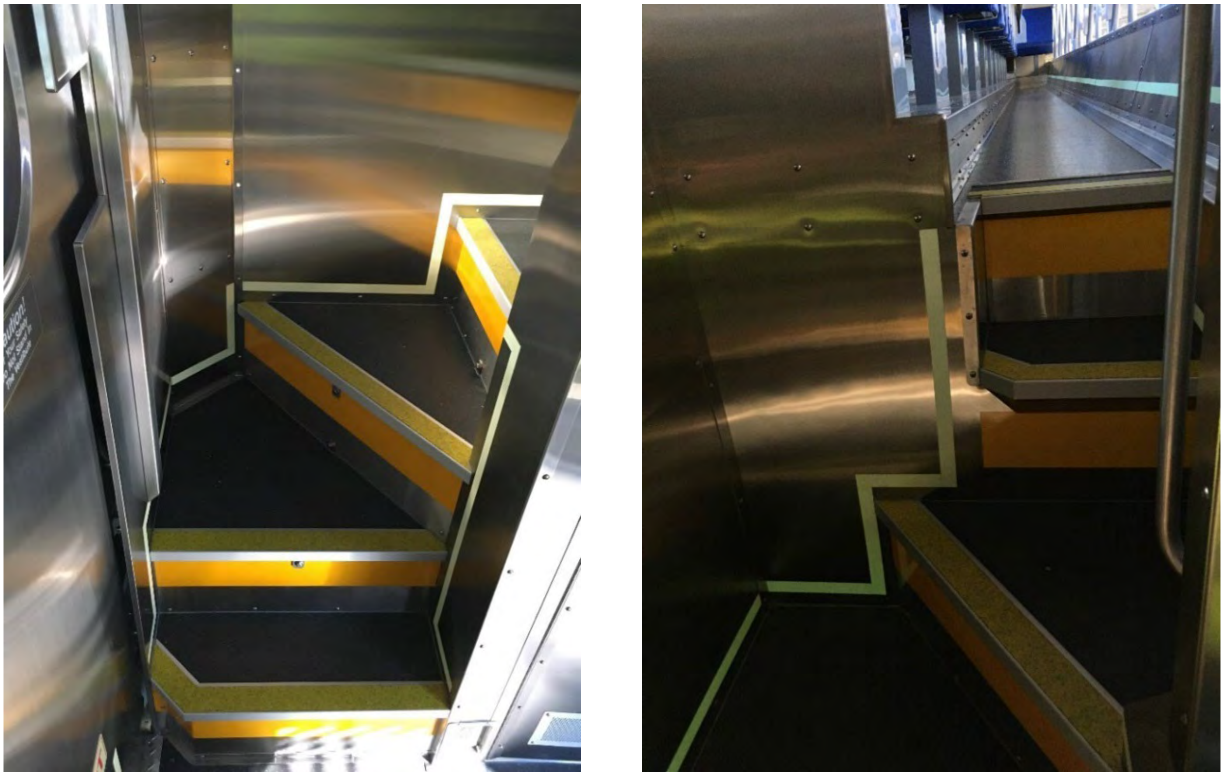
FIGURE 25
Non-Obvious Door Mechanisms Signage (UTA)

I.5 Stairway markings

I.5.1 Alternative 1 (as per Appendix G.2.2)

1 in. (2.5 cm) wide L-shaped marking/delineators shall be installed on both sides of each tread nearest to the wall.

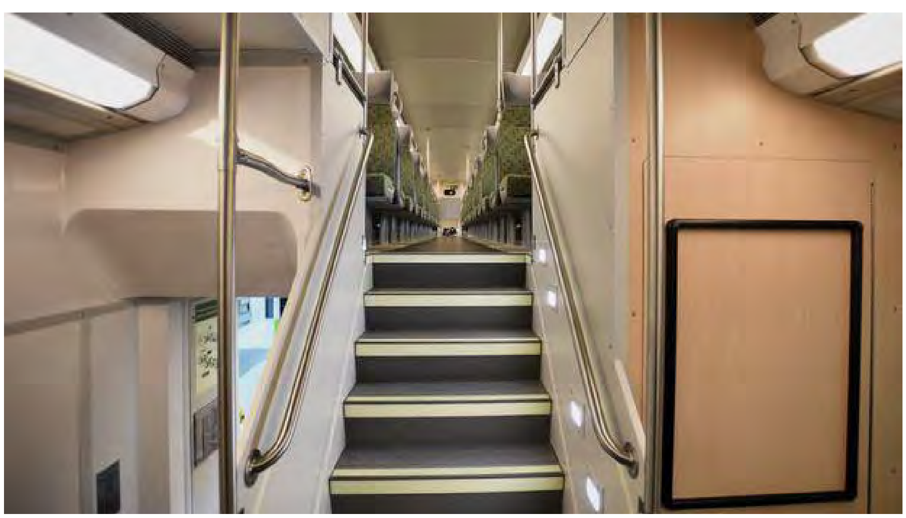
FIGURE 26
L-Shaped Stairway LLEPM Example (Nippon Sharyo)



I.5.2 Alternative 2 (as per Appendix G.2.2)

Materials applied to the step risers that consist of a minimum 2 in. (5.2 cm) wide strip or two 1 in. (2.5 cm) wide strips that extend, to the extent practicable, across the full width of the riser and placed at the lower half of the riser.

FIGURE 27
Wide Strip and Diagonal LLEPM Stairway Configuration (Bombardier)



I.5.3 Alternative 3 (as per Appendix G.2.2)

Discs of not less than 1.25 in. (3.18 cm) in diameter, placed either: 1) no more than 2½ in. (6 cm) apart on each stair tread, near the step nosing, or 2) no more than 2½ in. (6 cm) apart and no higher than 18 in. (45.7 cm) from the treads on both sides of the stairway walls/partitions.

FIGURE 28
Disc LLEPM Stairway Configuration (Bombardier)

I.6 External rescue signage

FIGURE 29
External Door Release (SEPTA)

FIGURE 30
Emergency Roof Access (SEPTA)

FIGURE 31
Rescue Window Demarcation (SEPTA)

Appendix J (informative): Section analysis

TABLE 2
Alignment Between Previous and Current APTA Signage and LLEPM Standards

Requirement	Signage Document (APTA PR-PS-S-002-99, Rev. 3) Section #	LLEPM Document (APTA PR-PS-S-004-99, Rev. 2) Section #	Current Document (PS-006) Section #
General system requirements	4	4	1
Visual identity and recognition, general system requirements	4.1	4.1	1.1
Multilingual signs, general system requirements	4.2	4.2	1.2
Design requirements, interior	5	5	2
Location, system design requirements	5.1 (interior only)	5.1	2.1
LLEPMs, design requirements and location	n/a	5.1.2	2.1.1
Electrically powered (active) LLEPM systems, design requirements and location	n/a	5.1.2.1	2.1.1.1
HPPL passive LLEPM systems, design requirements and location	n/a	5.1.2.2	2.1.1.2, G.2.2
Door exit locator signs, design requirements and location	5.1.1.2	n/a	2.1.2.
Door exits	5.1.1	5.1.1	2.1.3
Door-mounted signs, design requirements and location	5.1.1.1 (interior only)	n/a	2.1.3.1 (interior only)
Removeable panels	n/a	n/a	2.3.1.2
Routinely locked doors, door-mounted signs, design requirements and location	5.1.1.1	n/a	2.1.3.3
Failure en route, door-mounted signs, design requirements and location	5.1.1.1	n/a	2.1.3.3.1
Door exit delineators/markings, design requirements and location	5.1.1.1	5.1.1.2	2.1.3.4
Door exit control locator signs/markings and instructions, design requirements and location	5.1.1.3 (signs/markings), 5.1.1.4 (instructions)	n/a	2.1.3.5, G.2.1
Window exit locator signs/markings, emergency window exits, design requirements and location	5.1.2.1.	n/a	2.1.4.1
Window exit signs/markings and instructions, emergency window exits, design requirements and location	5.1.2.2.	n/a	2.1.4.2
Breakable emergency window exits	n/a	n/a	2.1.4.1.A
Grandfathered semi-permanently connected trainset LLEPMs	n/a	5.1.2	G.2.4
Letter and sign size, design requirements	5.2	n/a	2.2
Letter size, design requirements	5.2.1	n/a	2.2.1

TABLE 2
Alignment Between Previous and Current APTA Signage and LLEPM Standards

Requirement	Signage Document (APTA PR-PS-S-002-99, Rev. 3) Section #	LLEPM Document (APTA PR-PS-S-004-99, Rev. 2) Section #	Current Document (PS-006) Section #
Sign size, design requirements	5.2.2	n/a	2.2.2
Color and contrast, design requirements	5.3 (interior)	n/a	2.3
Illuminance/luminance criteria, design requirements	5.4	5.2	2.4
Electrically powered (active) systems, illuminance/luminance criteria, design requirements	5.4.1	5.2.1	2.4.1
LED minimum peak intensity and spacing, design requirements, electrically powered (active)	5.4.1.1	5.2.1.1	2.4.1.1
Individual light fixture average illuminance value, design requirements, electrically powered (active)	n/a	5.2.1.1	2.4.1.1
Incandescent mean spherical illumination and spacing, design requirements, electrically powered (active)	n/a	5.2.1.1	2.4.1.1
Average luminance, design requirements, electrically powered (active)	5.4.1.1	5.2.1.2	2.4.1.2
Externally illuminated minimum illuminance level, design requirements, electrically powered (active)	n/a	5.4.1.2	2.4.1.3
Passive HPPL systems, illuminance/ luminance criteria, design requirements	5.4.2	5.2.2	2.4.2
Materials, passive HPPL systems, illuminance/luminance criteria, design requirements	5.4.2.1	5.2.2.1	2.4.2.1
Charging light, passive HPPL systems, illuminance/luminance criteria, design requirements	5.4.2.2	5.2.2.2	2.4.2.2, Appendix B
Dual mode systems, illuminance/luminance criteria, design requirements	5.4.3.	5.2.3.	2.4.3.
Component materials, design requirements	5.5 (interior)	n/a	2.5
Vestibule, end-frame and side doors, component materials, design requirements	5.5.1	n/a	2.5.1., G.2.4
Additional requirements to mark side door exit locations without independently powered emergency lighting, component materials, design requirements	5.5.2	n/a	2.5.1.1.
Grandfathered systems and materials, design requirements	5.6	5.4	Appendix G
Design requirements, exterior	6	n/a	3

TABLE 2
Alignment Between Previous and Current APTA Signage and LLEPM Standards

Requirement	Signage Document (APTA PR-PS-S-002-99, Rev. 3) Section #	LLEPM Document (APTA PR-PS-S-004-99, Rev. 2) Section #	Current Document (PS-006) Section #
Rescue access door signs/markings, design requirements and location	6.1.1.1	n/a	3.1.1.1.
Rescue access door control signs/markings and instructions, design requirements and location	6.1.1.2	n/a	3.1.1.2
Rescue access windows, design requirements and location	6.1.2	n/a	3.1.2.
Roof emergency access, design requirements and location	6.1.3	n/a	3.1.3.
Letter size (exterior signs)	n/a	n/a	3.2
Color and contrast, exterior signs	6.2	n/a	3.3
Materials, exterior signs	6.3	n/a	3.4
Evaluation measurements and tests	7	6	4
Grandfathered systems, evaluation measurements and tests	7	6	G.1, G.3.3
Evaluation measurements and tests for interior signs/markings	7.1	6	4.1, B.3
Evaluation measurements and tests for Interior signs/markings, electrically powered (active) systems	7.1.1	6.1	4.1.1
Evaluation measurements and tests for Interior signs/markings, HPPL (passive) systems	7.1.2	6.2	4.1.2
Material luminance, evaluation measurements and tests for Interior signs/markings, HPPL (passive) systems	7.1.2.1	6.2.1	4.1.2.1
Ambient light charge, evaluation measurements and tests for Interior signs/markings, HPPL (passive) systems	7.1.2.2	6.2.2	4.1.2.2, B.3
Testing equipment, evaluation measurements and tests for Interior signs/markings, HPPL (passive) systems	7.1, Annex C	6, Annex C	4.1.3, Appendix C
Evaluation measurements and tests for exterior signs/markings	7.2	n/a	4.2
Recordkeeping for evaluation measurements and tests	7.3	6.3	4.3
Survivability requirements	9	8	5
Inspections	10	9	6
Daily inspections	10.1	9.1	6.1
Periodic inspections and tests	10.2, 10.2.1	9.2	6.2

TABLE 2
Alignment Between Previous and Current APTA Signage and LLEPM Standards

Requirement	Signage Document (APTA PR-PS-S-002-99, Rev. 3) Section #	LLEPM Document (APTA PR-PS-S-004-99, Rev. 2) Section #	Current Document (PS-006) Section #
Periodic inspections and tests for electrically powered (active) systems	10.2.1.1	9.2.1	6.2.1, E.1.1
Periodic inspections and tests for HPPL (passive) systems	10.2.1.2	9.2.2	6.2.2, E.1.2
Periodic inspections and tests for exterior signs/markings	10.2.2	n/a	Appendix E.1.2
Defect reporting, repair and recordkeeping	10.3	9.3	6.3

Appendix K (informative): Revision history of source documents

This standard is the combination of two previously existing standards. As it is a new document, it does not note the content changes in the body of the document. Instead, the revision histories of the component documents have been placed in this appendix.

K.1 Changes incorporated in this document

The original version of this standard contains the following changes from preceding standards, APTA PR-PS-S-002-98, "Emergency Signage for Egress/Access of Passenger Rail Equipment" and APTA PR-PS-S-004-99, "Low-Location Exit Path Marking":

1. Document formatted to the new APTA standard format.
2. Sections have been moved and renumbered.
3. Scope and summary moved to the front page.
4. Definitions, abbreviations and acronyms moved to the rear of the document.
5. New section added: "Document history."
6. Some global changes to section headings and numberings resulted when sections dealing with references and acronyms were moved to the end of the document, along with other cosmetic changes, such as capitalization, punctuation, spelling, grammar and general flow of text.
7. Names of participants updated.
8. Combining of existing Emergency Signage and LLEPM requirements.
9. In Section 1.1.2: addition of note regarding HPPL materials used in areas exposed to weather
10. In Section 2: reordering of locational requirements to that which each are encountered on the exit path.
11. In Sections 2.1.1.1.A and 2.1.1.2.A: marking requirements for single steps in passageways added.
12. In Section 2.1.1.2.B: rewording of acceptable interior stairway markings.
13. In Section 2.1.3.2: addition of removeable panel marking requirements
14. In Section 2.1.3.5: Created alternate marking requirements for pull chain door releases.
15. In Section 2.1.4.2.A: Addition of breakable emergency window provisions.
16. In Section 3.1.3: Addition of Emergency Roof Access marking requirements from APTA PR-CS-RP-001-98, "Passenger Equipment Roof Emergency Access."
17. In Section 3.2: addition of minimum sizing requirement for exterior emergency signage.
18. Removal of System Reliability requirements.
19. In Section 6: removed references to APTA inspection and maintenance standards.
20. Addition of definitions for "Alternative Door Exit," "Car Body End Door," "Car Body Side Door," "Door Exits," "Emergency Exit," "Emergency Windows," "End-Frame Door," "Exterior Side Door," "Instructional Signage," "Rescue Access Window," "Vestibule," and "Vestibule Door."
21. Addition of Appendix B.3, "Testing Considerations."
22. In Appendix F: Changed ANSI minimum sampling category from general II to S3. Removed simplified sampling method. Added guidance on the determination of fleet sizing for sampling purposes.
23. PL markings and grandfathered markings moved to Appendix G.
24. Added APTA Passenger Rail Emergency Systems Survey materials to Appendix H.
25. Added Appendix I for photographic examples.
26. Added Appendix J detailing the location of requirements from APTA PR-PS-S-002-98, Rev. 3, "Emergency Signage for Egress/Access of Passenger Rail Equipment" and APTA PR-PS-S-004-99, Rev. 2, "Low-Location Exit Path Marking."
27. Added Appendix K, Revision history from source documents.

K.2 APTA PR-PS-S-002-98, “Emergency Signage for Egress/Access of Passenger Rail Equipment”

Revision 1 of this standard included the following:

28. revisions to the Introduction
29. revisions to the Scope in Section 1, “Overview”
30. addition of the APTA emergency lighting standard (APTA PR-E-S-013-99) and other references to Section 2, “References”
31. renumbering of the bibliography to Section 3
32. renumbering of Section 3, “Definitions,” and Section 4, “Emergency egress/access signage,” to sections 4 and 5
33. addition and revision of certain definitions in renumbered Section 4
34. modifications to renumbered Section 5 that include revisions to increase the size, spacing and stroke-to-width ratio of sign letters; revision of sign color, contrast and legibility requirements; revision to require the use of high-performance photoluminescent (HPPL) material, if photoluminescent material is used for the interior door and emergency exit window signs and marking; and the inclusion of an ASTM test method reference for exterior signage/marking retroreflectivity.

Revision 2 of this standard included the following:

1. revision of Introduction
2. addition of a Table of Contents
3. reorganization of Scope in Section 1, “Overview”
4. addition of two 49 CFR citations in Section 2, “References”
5. relocation of the bibliography from Section 3 to a new Appendix A
6. renumbering of Section 4, “Definitions” to Section 3
7. renumbering of section headings and related text information formerly in Section 5 under two separate major headings: Section 4, “General system requirements,” and Section 5, “Design requirements”
8. renumbering of the remaining subheadings accordingly (this reorganization and revision was consistent with the reorganization and revision of those similar sections in the related APTA PR-PS-S-004-99, Rev. 1, “Low-Location Exit Path Marking”)
9. citation of an ASTM standard containing retroreflective material performance criteria Section 5
10. addition of three new Appendices, B–D, that provide guidance to railroads for evaluating HPPL material performance

Revision 3 of this standard included extensive modifications to facilitate the incorporation of the standard by reference by the FRA in 49 CFR, Part 238 (see explanation in next paragraph). In addition to the revision of the Introduction, these modifications included the following:

1. revision of Overview, Purpose and Scope in Section 1
2. addition and revision of definitions in Section 3
3. reorganization and extensive revision of Section 5, “Design requirements,” that also addresses grandfathering of certain signs/markings
4. deletion of Section 6, “Material Safety”
5. relocation and revision of provisions for exterior signage/markings and instructions, formerly in Section 5, to a new Section 6 and revision of the retroreflectivity criteria
6. transfer and revision of light meter requirements and HPPL laboratory tests and charging light test provisions that were formerly in Annex B to a new Section 7, “Evaluation measurements and tests”
7. revision and renumbering of former sections 6–8 to sections 8–10

8. revisions to former Section 9 (renumbered 10), "Maintenance," to include additional and revised daily and periodic tests, as well as clarified defect reporting, repair and recordkeeping.

In addition, as part of Revision 3, the annexes were revised:

1. The technical considerations information formerly in Annex D was revised and relocated to Appendix B.
2. HPPL test laboratory information in Annex C was revised and relocated to Appendix D.
3. Three new Appendices have been added that contain guidance for measuring HPPL charging light illuminance (Appendix C); automatic testing of emergency sign systems that use independent power sources (Appendix D); and representative sampling (Appendix F).

When FRA issued the final rule addressing Passenger Equipment Safety Standards in 1999, it identified various issues for future rulemaking, including those to be addressed following the completion of additional research, the gathering of additional operating experience, the development of industry standards, or all three. Passenger rail equipment emergency signage/marking is one such issue. APTA proposed to the Railroad Safety Advisory Committee (RSAC) Passenger Safety Working Group/Emergency Preparedness Task Force that this APTA emergency signage standard be incorporated by reference into 49 CFR, Part 238. Accordingly, APTA worked with the FRA, railroads, car manufacturers and suppliers, labor organizations, passenger organizations, and NTSB as part of the FRA RSAC process to prepare this revision of the standard in order to address the NTSB recommendation and to facilitate incorporation by reference of the standard into the FRA regulations. The RSAC Task Force had little difficulty reaching consensus on the revisions as they apply to new equipment. However, the debate on how to handle existing equipment proved to be more difficult.

At the time of publication, the modifications comprising Revision 3 of this standard affected equipment currently in service and/or new equipment in the following ways:

1. The option to use accelerated compliance with this standard as a remedy for failure to meet the emergency light levels required by APTA PR-E-S-013-99, "Emergency Lighting System Design for Passenger Cars," was eliminated.
2. Section 1.1, "Scope." The scope was revised to clarify that the standard does not apply to tourist, scenic, historic, excursion operations or private rail cars.
3. Section 1.2, "Purpose." The purpose of the standard was revised to require tests to validate the design of the emergency sign/marking system.
4. Section 3.1, "Definitions." Several definitions were added, including auxiliary power system, car, color temperature, dual mode, foot-candle, head-end power, independent power source, emergency lighting, normal lighting, luminaire, luminous intensity, and representative car/area. These additional definitions were necessary to clearly define requirements contained in the standard.
5. Section 3.1.13, "High-performance photoluminescent (HPPL) material." The definition of HPPL material was changed. Railroads and manufacturers requested this change to eliminate the need for more than one type of HPPL product to comply with the requirements in this standard. After Revision 3 of this standard took effect, railroads had to procure material capable of HPPL performance when subjected to a lower level of charging light.
6. Section 5.1.1.1, "Door signs/markings." When a door is locked, secured or otherwise inoperative, passengers must be directed to an alternative exit or operating instructions must be provided to open the inoperative door.
7. Section 5.1.1.2, "Door exit locator signs/markings." Additional signs/markings were required for the emergency/manual door release controls.
8. Section 5.1.1.3, "Door exit control locator signs/markings." Door exit control locator signs must be highlighted with outline stripping or an area wide pad of HPPL material.

9. Section 5.4.1.1, “Internally illuminated signs/markings.” The terminology used to describe active signage/marking systems was changed to allow newer technology, actively powered marking/delineator components.
10. Sections 5.4.2.2, “Charging light,” and 5.6, “Grandfathering of PL signs/markings,” including tables 1 and 2. Because fluorescent light sources are much more effective for charging HPPL material, fluorescent charging light sources were used as the basis for charging requirements. Different charging light levels were required when using different light sources (e.g., higher light levels are required when using incandescent lighting).
11. Sections 5.4.2.2, “Charging light,” 5.6, “Grandfathering of PL signs/markings,” 7, “Evaluation measurements and tests,” and “Annex C (informative): Procedures for measuring charging light illuminance.” The specifications for the light meter required to confirm charging light levels were revised and moved to the body of the standard. This means railroads/suppliers may have been required to buy new meters or adapters.
12. Section 5.5.1, “Vestibule, end-frame and side doors.” For passenger cars ordered before April 7, 2008, and placed in service before Jan. 1, 2012, all end and side doors leading to the exterior of the car must be marked by electrically powered, HPPL or dual mode signs/markings. In addition, this also meant that, for passenger cars ordered before Jan. 1, 2007, and placed in service before Jan. 1, 2009, beginning on Jan. 1, 2012, all newly installed or replacement end and side door signs shall use HPPL material or electrically powered sign fixtures with an independent power source.
13. Electrically powered independent power sources, HPPL material or dual mode must be used for emergency signs/markings for all end and side doors leading to the exterior of the car in all passenger cars ordered on or after April 7, 2008, or placed in service for the first time on or after Jan. 1, 2011.
14. Batteries that are used as independent power sources shall have automatic self-diagnostic modules designed to perform discharge tests.
15. Section 5.5.2, “Additional requirements to mark side door exit locations without independently powered emergency lighting.” A requirement to mark side door locations that do not have independently powered emergency lights with additional HPPL material by Jan. 1, 2009, was added.
16. Section 5.6 “Grandfathering of PL signs/markings.” As of April 7, 2008, all passive signs/markings must achieve HPPL performance or be specifically grandfathered.
17. Zinc sulfide signs in cars currently in service must be replaced, and existing stocks of zinc sulfide signs are no longer acceptable for installation as replacement signs because they do not meet HPPL performance.
18. Existing stocks of non–zinc sulfide photoluminescent material held in inventory as of April 7, 2008, can be installed only as allowed by Section 5.6, “Grandfathering of PL signs/markings.”
19. Section 6.1.2, “Rescue access windows.” Instructions for emergency rescue access windows intended for removal by emergency responders must be placed on or near each such window. Location of the instructions solely at the midpoint as well as the ends of the car is no longer permitted.
20. Section 6.1.3, “Emergency roof access.” Retroreflective emergency roof access locator signs/markings and instructions must be used on all cars equipped with roof hatches or roof structural soft spots.
21. Section 6.3, “Materials.” Additional requirements for protective coatings and color contrast of exterior retroreflective signs/markings were added.
22. Section 7, “Evaluation measurements and tests.” Requirements were added to the body of the standard for illuminance/luminance measurements and tests to verify that passenger car designs comply with this standard. These requirements were developed from material contained in the Annexes of Revision 2 of the standard. Revision 3 made them mandatory.
23. Section 7.1, “Interior signs/markings.” For equipment placed in service before Jan. 1, 2008, if a verification of compliance test on a representative car signage/marking layout had not already been completed, as required by Section 7, “Evaluation measurements and tests,” it was to be completed by Dec. 31, 2008.

24. Section 7.1, "Interior signs/markings." For new equipment, a verification of compliance test on a representative car/area, as required by Section 7, "Evaluation measurements and tests," must be completed before the car is put into revenue operating service.
25. Section 7.3, "Recordkeeping." A requirement to keep records of the illuminance/luminance measurements and tests made to verify initial designs was added.
26. Requirements for material safety contained in Section 6 of Revision 2 were deleted.
27. Section 8, "System reliability." More details were added to the system reliability requirements.
28. Section 9, "Operating conditions." For new passenger cars, a requirement for independent power sources to operate in all orientations as of Jan. 1, 2011, was added.
29. Section 10, "Maintenance." Extensive revisions were made and detail added to the periodic tests and inspection requirements.
30. Section 10.2.1.2, "PL (passive) systems." Testing of a representative sampling of cars comprising the fleet operated by the railroad must be done at an interval not to exceed eight years, to verify that the performance of the emergency signs remains in compliance with this standard.
31. All the informative annexes were extensively revised and reorganized, and new annexes containing new guidance information were added.

K.3 APTA PR-PS-S-004-99, "Low-Location Exit Path Marking"

Revision 1 of this standard included:

1. reorganization of Section 1, "Overview" (to include Scope)
2. renumbering of "References" to Section 2 and inclusion of citations for 49 CFR regulations, and ASTM and UL standards
3. addition of definition (marking) and inclusion of abbreviations and acronyms in Section 3
4. revision of Section 5 headings
5. movement of material safety to a separate Section 6 and renumbering of the remaining sections.
6. movement of the bibliography to Annex A
7. expansion of the information formerly contained in Annex A (now included in Annex D)
8. addition of two new annexes to provide railroads with extensive guidance for evaluating passive LLEPM material performance

Revision 2 of this standard includes extensive modifications to enable the incorporation of this APTA standard by reference by the FRA in 49 CFR, Part 238. These modifications included:

1. revision of the "Introduction"
2. revision of Purpose and Scope in Section 1, "Overview"
3. addition and revision of several definitions in Section 3
4. reorganization and revision of Section 4, "General requirements," and Section 5, "System design requirements"
5. deletion of Section 6, "Material safety"
6. relocation and revision of light meter requirements and HPPL laboratory tests and charging light test provisions that were formerly in Annex B to a new Section 6, "Evaluation measurements and tests"
7. revisions to Section 9, "Maintenance," to include additional and revised daily and periodic tests, and addition of defect reporting, repair and recordkeeping.

Finally, revisions were made to the annexes:

1. The technical considerations information formerly in Annex D was revised and relocated to Annex B.
2. Test laboratory information in Annex C was revised and relocated as Annex D.

3. Three new annexes were added that contain guidance for, HPPL charging light illuminance measurement (Annex C), automatic testing of LLEPM systems that use independent power sources (Annex E), and representative sampling (Annex F).

As FRA was considering requiring the installation of LLEPM systems on passenger rail equipment, APTA proposed to the Railroad Safety Advisory Committee (RSAC) Passenger Equipment Working Group/ Emergency Preparedness Task Force that this APTA LLEPM standard be incorporated as a reference into 49 CFR, Part 238. Accordingly, APTA worked with the FRA, railroads, car manufacturers and suppliers, labor organizations, passenger organizations, and NTSB, as part of the FRA RSAC process, to prepare Revision 2 of this standard in order to address an NTSB recommendation and to facilitate the incorporation by reference of the standard into the FRA regulations. The RSAC Task Force had little difficulty reaching consensus on the revisions as they apply to new equipment. However, the debate on how to handle equipment currently in service proved to be more difficult.

At the time of publication, the modifications comprising Revision 2 of this standard affected equipment currently in service and/or new equipment in the following ways:

1. Section 1.1, "Scope." The date by which full compliance must be achieved was extended from Jan. 1, 2006, to Jan. 1, 2009. Exceptions were allowed in Section 5, "System design requirements."
2. The option to accelerate installation of LLEPM systems to meet emergency light levels required by APTA SS-E-013-99, "Emergency Lighting System Design for Passenger Cars," contained in Revision 1 of this standard was eliminated.
3. Section 1.1, "Scope." The scope was revised to clarify that the standard does not apply to tourist, scenic, historic, excursion operations or private rail cars.
4. Section 1.2, "Purpose." The purpose of the standard was revised to require tests to validate the design of the emergency sign/marking system.
5. Section 3.1, "Definitions." Several definitions were added, including auxiliary power system, car, color temperature, dual mode, foot-candle, head-end power, independent power source, emergency lighting, normal lighting, luminaire, luminous intensity, representative car, secondary exit, sign, spatial average and useful field of view. These additional definitions were necessary to clearly define requirements contained in the standard.
6. Section 3.1.13, "High performance photoluminescent (HPPL) material." The definition of HPPL material was changed. Railroads and manufacturers requested this change to eliminate the need for more than one type of HPPL product to comply with the requirements in this standard. Some passive LLEPM system components may have needed to be replaced or some illumination levels increased.
7. The equivalency review committee requirement contained in Revision 1 was eliminated and was replaced with greater flexibility in the installation of the LLEPM system.
8. Section 5, "System design requirements." The requirement for the LLEPM system to visually mark an exit path in two directions was deleted and replaced with new requirements for alternate exits that must be followed when a car has only one primary exit. Railroads are required to use their passenger awareness programs to alert passengers in these cases.
9. For passenger cars ordered before April 7, 2008, and placed in service before Jan. 1, 2011, electrically powered path markings/delineators that are not dual mode shall have an independent power source by Jan. 1, 2012.
10. Section 5.1.2, "Exit path marking/delineators." Batteries that are used as independent power sources shall have automatic self-diagnostic modules designed to perform discharge tests. An exception was allowed for certain semi-permanently coupled train sets by Jan. 1, 2012.
11. Sections 5.1.2.1, "Electrically powered (active) systems," and 5.1.2.2, "HPPL (passive) systems." Additional flexibility was included in cases where car interior configuration makes compliance with the maximum permitted spacing between markings/delineators/light fixtures not practicable.

12. Section 5.2.1, “Electrically powered systems.” The terminology used to describe active LLEPM systems was changed to allow newer technology, actively powered marking/delineator components.
13. Section 5.2.2.2, “Charging light,” Table 1. Because fluorescent light sources are much more effective for charging HPPL material, fluorescent charging light sources were used as the basis for charging requirements. Different charging light levels were required when using different light sources (e.g., higher light levels were required when using incandescent lighting.
14. Sections 5.2.2.2, “Charging light,” and 6, “Evaluation measurements and tests,” and “Annex C (informative): Procedures for measuring charging light illuminance.” The specifications for the light meter required to confirm charging light levels were revised and moved into the body of the standard. This means some railroads/suppliers may have had to buy new meters.
15. Section 5.3, “Grandfathering of LLEPM PL components.” As of April 8, 2008, all passive LLEPM system components must achieve HPPL performance or be specifically grandfathered.
16. Sections 3.1.13, “High performance photoluminescent (HPPL) material,” and 5.3, “Grandfathering of LLEPM PL components.” Zinc sulfide passive components in cars currently in service must be replaced and existing stocks of zinc sulfide components are no longer acceptable for installation as replacements because they do not meet HPPL performance
17. Existing stocks of non–zinc sulfide photoluminescent material held in inventory as of April 7, 2008, can be installed only as allowed by Section 5.3, “Grandfathering of LLEPM PL components.”
18. Sections 5.2, “Illuminance/luminance criteria,” and 6, “Evaluation measurements and tests.” Requirements were added to the body of the standard for illuminance/luminance measurements and tests to verify that passenger car designs comply with this standard. These requirements were developed from material contained in the annexes of Revision 1 of the standard. Revision 2 made these measurements and tests mandatory.
19. Section 6.1, “Electrically (active) powered systems.” For equipment placed in service before Jan. 1, 2008, if a verification of compliance test on a representative car LLEPM layout had not already been completed, as required by Section 6, “Evaluation measurements and tests,” it was to be done by Dec. 31, 2008.
20. Section 6.1, “Electrically (active) powered systems.” For new equipment, a verification of compliance test on a representative car/area, as required by Section 7, “System reliability,” must be completed before the car is put into revenue operating service.
21. Section 6.3, “Recordkeeping.” A requirement to keep records of the illuminance/luminance measurements and tests made to verify initial designs was added.
22. Requirements for material safety contained in Section 6 of Revision 1 were deleted.
23. Section 7, “System reliability.” More detail was added to the system reliability requirements, including a date extension for LLEPM components to function independently of the main car battery to on or after Jan. 1, 2012.
24. Section 8, “Operating conditions.” For passenger cars ordered on after April 7, 2008, or placed in service for the first time after Jan. 1, 2011, a requirement for batteries or other independent power sources to operate in all orientations was added.
25. Section 9, “Maintenance.” Extensive revisions were made and detail added to the periodic test and inspection requirements.
26. Sections 9.2.1, “Electrically powered (active) systems,” and 9.2.2, “PL (passive) systems.” Testing of a representative sample of the railroad car fleet must be done at an interval not to exceed eight years to verify that the performance of the LLEPM components remains in compliance with the standard.
27. Section 9.3, “Defect reporting, repair and recordkeeping.” An explicit requirement was added to repair LLEPM defects found during periodic inspections.
28. All the informative annexes in Revision 1 were extensively revised and reorganized, and new annexes containing guidance information were added.

